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SPECIAL ISSUE

The Pathology of Reproduction

By W. L. Williams

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Disease Incident to Animal Breeding

The diseases incident to reproduction occasion greater loss to the live stock industry of this country than any other group of diseases. This is true, even if mastitis, an interference with a reproductive function, be excluded. No elaboration of the foregoing is required to emphasize the importance of these diseases to the live stock industry or their concern to veterinarians.

Losses incident to reproduction have occurred, in all probability, since animals were first domesticated by man and brought under the changed environment that domestication entails. While ancient and medieval literature contain references to abortion and sterility in animals, it is not alluded to in the category of great animal plagues, that periodically swept over the civilized world, decimating the live stock and impoverishing the people. Granting that abortion is due to infections, the conclusion seems inescapable, when its activity is viewed throughout recorded history, that this contagion has not performed like the contagions of hog cholera or foot-and-mouth disease, or glanders, or anthrax, or tuberculosis, but more like the organism causing hemorrhagic septicemia, or necrosis, or pneumonia, in that it has required special conditions under which to thrive—that the normal resistance to it possessed by the animal organism be depressed before it could invade the animal and cause morbidity, sterility, or death.

The ancients knew something of the control of abortion and sterility. We have not demonstrated that we know more about the practical handling of it than they did. Jacob cited to Laban, the Syrian, that he had prevented abortion in the latter's herds. The results show the herds were not troubled with sterility, either. Jacob was learned in genetics; he speaks of keeping many males. The inference is that he relied upon sexual hygiene to prevent abortion; the record shows he was successful.

Sexual hygiene, as a means of controlling disease, incident to reproduction, was the main reliance until about the close of the eighteenth century, when isolation came into use. Apparently, abortion in cows and mares, particularly in the latter, was becoming increasingly important. The veterinary profession of that day was thoroughly familiar with the occurrence of abortion if not with its cause. Veterinarian James White, writing in 1817, gave a description of abortion as lucid as that of Hutyra and Marek. He outlined a plan for isolation and quarantine of affected animals as complete and practical as the regulations in force today. Of present day information on this subject, he lacked only that revealed by the microscope, the bacteriological laboratory, and of the serum test.

Eighty years after White published his Dictionary of The Veterinary Art, Bang announced the discovery of the *B. abortus* (in 1897) and predicted that an immunizing agent would be perfected that would eliminate loss from it in cattle; or failing that, the disease could be controlled completely by quarantine. The increase in the prevalence of abortion and sterility since that prediction was made has been greater than in all preceding history. Nevertheless, Bang's method —vaccination—remains the most widely used means of control. There is no unanimity of opinion as to whether or not vaccination has justified itself by its results.

About ten years ago a plan for the control and eradication of Bang's disease in cattle—isolating and segregating animals on the basis of a positive reaction to the agglutination test—was inaugurated officially in Pennsylvania. Modifications of this plan have been adopted officially in Illinois, Kansas and some other states. In Wisconsin, an isolation-segregation-sanitation plan has been adopted officially that differs from the others chiefly in that it is carried out entirely by veterinary practitioners; the officials merely exercising a supervision of the work. It possesses an immense advantage over the other plans in that the cattle owner has near at hand, at all times, expert veterinary advice for which he is paying directly (not indirectly in his tax bill as in the other plans) and therefore is inclined to heed. The veterinarian in charge has the herd under constant observation and in time becomes thoroughly familiar with its peculiarities. His advice as to its management is obviously more valuable to the owner than any long distance instructions from official sources. Again, there is no unanimity of opinion as to whether these methods, or any of them, have justified themselves by results.

In recent years, there has been much research into this subject. Some of the findings have been contradictory. Particularly is this true with regard to the effectiveness of vaccination as a measure for the control of Bang's disease. The research leaves unanswered questions of importance. Why is abortion far more prevalent in dairy than in beef cows? Why has it increased enormously in prevalence in dairy cattle during the last thirty years and little if any in beef cows, mares, sows, or ewes? What is the factor that makes it a catastrophe in a dairy and only a misfortune in a beef herd?

Doctor Williams, who has given this subject longer study than anyone else in America, and whose opportunities for clinical observation have exceeded those of anyone else, frankly holds that abortion, sterility, retained after-birth, dystocia, monstrosities, etc., all are accompanied by infection or were preceded by infection in the life of the individual; but that the infection is secondary, bad sexual hygiene being the primary or predisposing cause. Undetermined amounts of this infection consist of Brucella organisms, other (?) pyogenic organisms and one or more filtrable viruses.

To Doctor Williams, the foregoing questions propound no mysteries. They all have been answered already by carefully controlled research and abundant clinical observation. Infection is ever present. Its *role* in the diseases incident to reproduction in animals is somewhat analagous to its presence in an operative wound. However aseptic the surgery may have been, if the surgeon leaves a large blood clot in the wound, he may confidently expect infection to develop. All that infective organisms require is an opportunity. In the pathology of reproduction this opportunity is provided in the lowered resistance of the gravid uterus due to bad sexual hygiene, or other depressing influences. How this lowered resistance is brought about is abundantly explained in the discussion which follows.

If any justification were required for the large amount of space devoted to this subject, it is to be found in the first paragraph of this article. It may be pointed out with advantage, however, that although the examples cited in the discussion are drawn chiefly from the bovidæ, the principles apply equally to all other domestic animals; so far as sterility, or its concomitant evils, concern the veterinarian whose practice is chiefly with horses, swine or pet animals, the discussion is pertinent.

The Pathology of Reproduction in Domestic Animals*

By W. L. WILLIAMS

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Lecture No. 1.

THE PATHOLOGY OF REPRODUCTION IN PERSPECTIVE

The diseases of mammals are divisible into two great groups: antenatal and postnatal. They blend at various points. The intrauterine individual does not become diseased and die without causing some injury to the uterus or other portion of the reproductive system of the pregnant female, but such injury may not be readily visible, clinically. Conversely the uterus or other reproductive organ may not be diseased without adversely affecting the contained young.

The mortality of intrauterine young is relatively far higher than in postnatal life. The sow produces at a given estrum, 15 to 25 ova, most or all of which are fertilized but upon the average not over 6 to 10 pigs are born, the others having died within the brief space of four months. In the uniparous mare and cow, two or more services are required as a rule for each young produced, although it is fairly certain that most ova are fertilized. Intrauterine death is not the full measure of the loss from antenatal disease. Many diseases and deformities of young and adult mammals are definitely traceable to antenatal pathology.

The economic losses from antenatal pathology in domestic animals is by far the greatest in dairy cattle. The ultimate object of the dairyman is the production of a profitable quantity and quality of milk; calves are a dairy byproduct. The milk glands are adjuncts of the reproductive system and lactation is dependent upon the reproduction of young at frequent intervals. The dairy cow is thus asked to bear a dual load, the production of calves and of a volume of milk grossly in excess of the physiological plan.

Disease, almost wholly sexual, steps in, and many dairy herds fail to produce sufficient female progeny for replacement. The principles involved in the pathology of reproduction are alike in all animals. The variations in the incidence and destructiveness of genital disease in different species and groups of animals must be attributed to the operation of various forces, the intensity of which is modified by environment. Some of these forces are clearly recognizable, others are undetermined. If it be attempted to compare some of the important variations in environment which may modify the invasive power of disease as related to the strength of the animal to resist it, dairy cattle and sheep offer the following marked contrasts:

1. The dairy calf is grown artificially, generally upon unnatural food; the lamb is grown naturally.

2. The dairy calf is the most frequently and dangerously diseased of any young domestic animal; the lamb is very healthy.

3. The dairy heifer is commonly bred when far less mature than is the ewe lamb when first bred.

4. The dairy heifer, immediately following her first calving, is asked to assume the heavy load of commercially profitable lactation; lactation in the ewe is limited to the needs of her young.

5. The dairy cow is often rebred at 30 days after the termination of preg-

*A series of addresses delivered before the Veterinary Short Course at the Alabama Polytechnic Institute, Auburn, Alabama, February 1-6, 1932.

nancy, usually at 60 or 70 days, while in full lactation, and required to carry the double load of pregnancy and lactation for 7 to 8 months; the ewe enjoys a respite of seven months in pregnancy, 2 or 3 months of which is free from the moderate lactation; she enjoys a definite rest period from both gestation and lactation.

6. Dairy cattle unquestionably suffer most severely from diseases of reproduction of any group of domestic animals; ordinary sheep are sexually the most healthy and efficient.

The significance of the foregoing contrasts will be variously interpreted by different persons. The determination of the causes of these contrasts should point the way toward improvement in reproduction. The pathology of reproduction is a highly complex problem. The factors involved are infinite; each reacts upon all the others, rendering it impossible to arrive at a safe conclusion through a close-up study of a single influence. It is necessary instead, that a study be made of as many of the forces as possible, both in detail and collectively.

Throughout the history of animal industry, interferences with reproduction have been recorded and have at times attained definite economic importance. In recent times the problem has become one of the first magnitude to breeders and a definite challenge to the veterinary profession.

Reproduction is a luxus function; it is not physiologically called into play, until the individual has attained such a degree of maturity and strength, that it may safely undertake this additional burden. That reproduction is not essential to the life or health of the individual, is illustrated by the neuter or freemartin calf; by the mule, and by castrated animals.

The effective study of the pathology of reproduction is peculiarly difficult. The fertilized ovum, at first microscopic, is hidden away where it can not be observed directly in its living state. Not only has it been difficult to discover the facts regarding the pathology of reproduction, but until recently the problem has been of relatively minor importance; when compared with various animal plagues, the control of which commanded the best efforts of the veterinary profession.

In the same year that I entered the veterinary profession, fifty-three years ago, Professor Walley of Edinburgh published a pretentious volume entitled "The Four Bovine Scourges." He frankly admitted the existence of other odds and ends of disease, but regarded the four named as constituting all those of major importance to the cattle industry of Great Britain. Concerning the first three of his list (contagious pleuro-pneumonia, cattle plague, and foot-and-mouth disease) he takes no pains to defend his classification of them as scourges of the first magnitude. He apologizes, and enters upon a lengthy defense for having included tuberculosis because at that time it was commanding scant attention.

In the United States rinderpest is unknown; few veterinarians have seen pleuro-pneumonia, and not very many have observed foot-and-mouth disease. There is no denial now that tuberculosis is a scourge of the first magnitude; but available evidence seems to indicate clearly that it is being repressed to a hopeful degree, and that in due time it will be eliminated, or at least reduced to a minor problem. Texas fever has caused greater losses to the cattle industry of the United States than Walley's first three scourges combined; but it seems now well on the road to elimination. Meanwhile the pathology of reproduction has forged ahead until it takes precedence in economic importance and in the difficulties of control over Texas fever and tuberculosis combined.

Genital disease is not the sole result of any one pathogenic organism or factor, nor can any approximately complete list of important causes be made at this time. Fertilized ova, embryos and small fetuses perish from disease, in great numbers, and disappear unseen; the causes of their death commonly escaping detection. Some embryos, which become attacked by disease, partially recover to ultimately result in monsters or in other aberrations of less severe type. Some of the lesser aberrations are not wholly incompatible with life but the de-

fects, such as umbilical and scrotal herniae, may at any time menace the health or life of the defective animal.

The pathology of reproduction, as such, is commanding little attention in the United States. Some Continental European countries have provided extensive facilities, with well trained personnel, for a comprehensive study of the forces which interfere with reproduction, in all economically valuable domestic animals; in Germany there is a large and vigorous association of scientists engaged in this field, who meet for the discussion of their problems.

Such research organizations do not exist in the United States. Instead there have been organized by federal and state bureaus of animal industry, by agricultural experiment stations, and by agricultural, and veterinary colleges, extensive equipment and ample personnel for researches upon those abortions and other phenomena in cattle attributed to *B. abortus* (Bang). More men are engaged in these researches, and more funds are being expended upon them, than ever before have been devoted to investigations upon any two diseases, in the history of veterinary science in America. This attitude of the federal and state governments is apparently based upon the hypothesis that Bang's bacillus is the central force in the pathology of reproduction in cattle, about which all other important causes revolve as satellites. In spite of the great volume of effort no clearly established discoveries have yet been made which have definitely halted, or retarded the pathology of reproduction as a whole, or of the prevalence of Bang's bacillus in particular. If all cattle, responding to an accepted test for the presence of Bang's bacillus, are removed from a herd and slaughtered, they undeniably provide no further abortion, sterility, or other pathological phenomena. Definite records are not available, however, showing that the elimination of the convicted animals, has enabled the remaining cows to attain, or closely approach, the ideal rate of reproduction. The cost of such eliminations is not authentically reported, and the actual efficiency of the remaining animals is not recorded in detail, but categorically only.

The measures devised for the control of genital disease vary widely. Essentially all governments quarantine dourine and usually destroy affected animals. Most Continental European states quarantine against the vesicular venereal disease or coital exanthema; but so far as known, neither the federal nor any of the state governments of America, takes official cognizance of it, although it is not rare in either horses or cattle. Some thirty states and territories of the United States quarantine against the importation of cattle classed as affected with Bang's bacillus, but place no restrictions upon animals because of other disease of the genital organs however virulent. In Continental Europe quarantine measures, against Bang's bacillus, are wanting or lax.

In the United States and in other countries there are no well established sanitary regulations for the control of Bang's bacillus within the state. In some communities, efforts are being made to eliminate cows diagnosed as harboring Bang's bacillus, from herds supplying market milk, as a means of repressing undulant fever. This is not necessarily related to the breeding problem. Many advocate the isolation or discard of all animals, classed as harboring Bang's bacillus. Other equally prominent individuals and organizations, perhaps equal in numbers to the foregoing, advise that all cattle in a herd, where Bang's bacillus exists, be inoculated with the live organism. The inoculation with living bacilli in herds, where the existence of Bang's bacillus is not recognizable, is generally disapproved. Large herds, in which Bang's bacillus does not exist, are so extremely rare, that the suggested exclusion of inoculation is not of great interest to the cattle industry, nor does it restrict materially the vaccine market.

The removal from a breeding herd of those animals seriously affected with genital disease, which can not be economically salvaged, is in full accord with the principles of hygiene. But the removal does not benefit the removed animals, and can not prevent the remaining animals from later developing destructive genital disease of some

type. In some herds, but by no means in all, the published data show that those cows, the blood of which reacts to the test for Bang's bacillus, breed less satisfactorily than the negative cows. Even in such herds the evidence is commonly defective and incomplete. Lothe[9] has shown that in a large herd abortions were most numerous in the positive cows but a detailed study of his excellent data shows that the abortions in the positive group quite largely had occurred while the cows were yet negative; they became positive subsequent to the abortion. This raises the interesting question of whether in some cases Bang's bacillus is the basic cause of the abortion, or whether some other bacillus, virus or other influence first causes important genital disease and prepares a suitable environment in which Bang's bacillus may multiply destructively. There is sufficient evidence of the latter to challenge careful study.

Bang's bacillus is apparently a pyogenic organism and is intimately associated with purulent inflammation of the placental tissue and the development of abscesses in solipeds, ruminants and swine. It is prominently associated with abortion, because of which it has been extensively studied, and has thereby become the most favorable standard for the consideration of genital diseases as a whole. It is now well known that a long list of other bacteria are frequently present in abortion, premature birth, retained afterbirth and other types of genital disease; as well as within the uterus, fetal membranes and fetus, in clinically physiological birth.

Bacteria do not comprise all the forms of pathogenic life associated with genital disease. It is well known that the vesicular venereal disease or genital exanthema of horses and cattle, like other diseases characterized by vesicular eruptions, is due to a filterable virus in each. How many other filterable viruses may be associated with genital diseases of domestic animals, is purely speculative. One of the most profoundly destructive diseases of reproduction is dourine of horses, due to a trypanosome. Trypanosomes are common in the blood of cattle; it has been claimed by some that this parasite is the cause of the granular venereal disease or nodular vaginitis. There are important clinical evidences in support of the contention. If this be true of cattle, it should logically follow also in other ruminants and swine, in which the granular venereal disease is widely disseminated. It is therefore desirable when studying the pathology of reproduction in perspective that these three great groups of contagions: bacteria, filterable viruses and protozoa be kept in mind, especially since it is well known that representatives of each group have an important place in these diseases.

Abortion; as well as other pathological phenomena of reproduction, such as premature birth, stillbirth, dystocia, monsters, and retained afterbirth, is by far the most prevalent in cattle. The destructiveness is not alike in all breeds but is preëminently most severe in dairy cattle. It is a general principle, based upon clinical experience, that when contagion invades a herd or group, some individuals fail to become diseased; they are said to be more resistant. In some maladies, especially in a large proportion of those due to filterable viruses, like foot-and-mouth disease, few exposed animals escape. In many infectious diseases only a minority contract the malady, promptly; especially is this true in chronic bacterial diseases. Finally the border line of contagious disease is reached where contagion occurs chiefly, or only, in the presence of profound depression of vigor or of notable traumatic injury. Thus, according to apparently reliable authority, the organism of hemorrhagic septicemia is virtually universally distributed, but becomes a cause of important disease, only when the animals involved are depressed greatly from other agencies. The pus-producing bacteria generally act only in a wound, although virtually always present.

Why are dairy cattle overwhelmingly more vulnerable than range, beef cattle, to invasion by Bang's bacillus, and other species of bacteria associated with abortion, and other sexual diseases? If the

question is answerable there should follow logical hope for improvement in the breeding health of dairy cattle. Neither isolation nor vaccination can well change dairy cattle to the status of range, beef animals. Recently I have studied closely, very severe genital disease in a dairy herd. Separated from these dairy cattle by only a wire fence, were 25,000 beef cattle, comprising about 7,500 breeding females. Neither dairy nor beef cattle are stabled, and the forage is as nearly alike as can grow upon opposite sides of a wire fence. The beef herd has existed for a century; there is no record of serious genital disease and the rate of calf production is high. Within ten years after the establishment of the dairy herd, severe genital disease had become established, without recognizable introduction.

In dairy herds abortion and other disease phenomena are not uniformly distributed amongst the animals. In many dairy herds, heifers furnish half or more of all abortions, premature births, dystocias, retained afterbirths and other types of genital disease. In beef cattle, females in the second pregnancy commonly suffer most. Why this contrast? I will attempt to answer this question later.

It is frequently claimed, that dairy heifers suffer so severely because they have not yet become immune to the bacteria causing the disease. The fact, that the heifer aborts conclusively proves her vulnerability, but does not explain why the range beef heifer, on the other side of the wire fence, does not abort. Hence an experimenter may show, that he can reliably "cause" abortion, by inoculating the heifers on one side of the fence with Bang's bacillus; while another experimenter may prove conclusively that he can "prevent" abortion, by applying the same measure to the heifers on the opposite side of the fence—but they need be careful not to get the two groups transposed. Once a heifer has aborted, tradition has it that she is thereafter immune. Clinical observation flatly denies the tradition. Sterility is extremely common in those heifers which abort in first pregnancy or suffer from dystocia, retained afterbirth or other equally important type of sexual disease. Among those which again become pregnant, a far higher ratio have a pathological termination of gestation, than is the case among those heifers in which the first pregnancy terminated physiologically.

A dairy cow which has passed through her first two pregnancies physiologically, usually breeds well up to ten to twelve years of age, after which the abortion-sterility-retained-afterbirth ratio advances rapidly and closely approaches that in heifers in first pregnancy. Such cows are exceptionally healthy, until old age lowers their vigor and renders them less able to bear the load of reproduction and lactation. Disease is then more destructive in them than in heifers in first pregnancy. The young heifer, which aborts, is moving upward, toward higher maturity and strength, and if not too badly injured, may improve sufficiently to breed acceptably for a time; but when the aged cow falters, and goes down, the outlook for the resumption of acceptable breeding is well-nigh hopeless. She does not become "immune" and go on breeding for another decade. A few cows breed splendidly up to 20 to 25 years; but not because they had aborted as heifers and became immune to sexual disease.

Results, which appear contradictory, are also observed in experiments with abortion. I injected 10cc of an emulsion of living Bang bacilli into the jugular veins of each of six pregnant heifers. One died from tuberculosis. After allowing the remaining five an abundance of time to abort, which they obstinately refused to do, they were killed, and a careful search of their uteri and contained fetuses failed to reveal any trace, past or present, of the bacillus. Two colleagues at approximately the same time conducted a parallel experiment upon five cows; all promptly aborted and the aborts contained Bang's bacillus. The cultures were made in the same laboratory, by the same man, and I made the injections in all, with the same syringe. My heifers were about

one-half the weight of my colleagues' cows; so that the heifers had double the volume of culture, per unit of body weight.

According to tradition and current theory, the heifers should have been highly susceptible and the cows immune. Inquiry showed that genital disease had raged the preceding year in the herd from which the cows came; and that only one of the five had produced a calf. This, according to theory, should have rendered the cows highly immune. My heifers were nondescripts, obtained from a local cattle trader with the characteristic absence of history in such cases. No two experiments could be more contradictory. An authentic explanation would be highly valuable. No evidence was obtained, which showed or tended to show, that the bacilli injected into the cows did not play an important part in causing the abortions. Perhaps had I multiplied the dose of bacilli to the heifers ten to twenty times they also would have aborted. It was clearly shown that the injection into the jugular of 10cc of an emulsion of Bang's bacilli, of the degree of virulence used, does not cause such heifers to abort. One critic dismissed the evidence with the remark that I had "used exactly five heifers." I admit that there were to the best of my knowledge exactly five heifers, not 4.3 nor 4.9. I have never advocated the use of fractions of heifers in scientific experiments.

Subsequent to the date of the above experiments, some colleagues and I[17] authentically showed, that abortion is regularly the consequence of utero-chorionic lesions. The damage to the endometrium persists throughout the life of the animal. My critic, who charged me with having used exactly five heifers, might have added, with due fairness, that my colleagues did not use "exactly" five cows; but used instead five remnants of cows, the extent of each remnant being unknown. Each of the cows had lost an undetermined part of the placental tissues of her uterus, which had left the organ decreased in area and depressed in vigor. The conclusion is justifiable, if not inescapable, that without having known it, I had purchased five heifers, which were so healthy that they ignored the introduction of the bacilli into their veins; while my colleagues, equally uninformed, purchased five cows which were too far from healthy to withstand the force of the inoculation.

That is not the whole story. Some prominent investigators have stated, recently, that in the control of Bang's disease, a wire fence constitutes an effective barrier. There was a fence in this case but both groups were on the same side of it. The heifers having proved invulnerable to the injections of Bang bacilli into their jugulars, offered no menace to the cows—they did not have Bang's disease. The cows aborted in the pasture and the heifers became luxuriantly exposed naturally. For all that, the heifers went serenely along. Various theories may be advanced to evade or obscure the observations. An authentic explanation, of the basic cause of this remarkable difference in susceptibility, is worth inexpressibly more than volumes of theory. The important problem is to discover the nature of the resistance exhibited by the five heifers, and the means by which such resistance may be obtained and perpetuated.

Few proposed remedies have been more widely used for the control of animal disease, than the inoculation of dairy cattle with living Bang bacilli. Its advocates have maintained, stoutly, that when used as a preventive, the injection does not cause disease. A considerable ratio of heifers and cows are like the five heifers described above and ignore both artificial and natural exposure. The resistance of such cattle has probably saved the dairy industry from appalling losses.

Bang's bacillus (and presumably most other bacteria and viruses) invading the uterus does not limit its invasions to cattle, but is recognizable in numerous species of mammals and birds. Its exact range of dissemination is undetermined. It does not show a predilection for the reproductive organs in all species. The phenomenon of abortion was mistaken for a disease and out of the error grew the terms "contagious abortion" and "abortion disease." Thus abortion came to be regarded as a female disease. It was found, however, that Bang's bacillus, so frequently associated with abor-

tion in cattle, invades both males and females. In cattle of breeding age, the bacillus is recognized far more frequently in the female. There are many more females than males in breeding. In other species of animals Bang's bacillus is recognized as frequently in males, as in females; while in man the incidence of undulant fever is thrice as great in men as in women. In cattle a great majority of the aborted fetuses are males. Pathogenic bacteria are quite often difficult, or impossible, of recognition, until disease has become established and the bacilli have become concentrated in the diseased area and have multiplied enormously.

In man, Bang's bacillus is associated prominently, not with genital disease, but with a bacteriemia known as undulant fever, with a highly interesting variation in incidence, according to age and sex. In the contribution by Zeller,[22] amongst 617 cases diagnosed and the sex recorded, 69.7% were males and 30.3% females. The incidence of undulant fever, according to sex, is apparently the reverse of the diagnosed presence of Bang's bacillus in cattle. Bacteriemia due to Bang's bacillus is not known to occur in cattle during postnatal life; but aborted fetuses, with which the Bang organism is associated, commonly show signs of having suffered from bacteremia. The same is true, however, of aborted bovine fetuses in which the presence of Bang's bacillus is not recognizable. The contribution of Hart and Carpenter,[4] in whose experiments the inoculated heifers developed inoculation abscesses and severe emaciation, suggests bacteriemia. It is commonly held, that Bang's bacillus is transported by the blood stream of cattle from the alimentary tract, after ingestion, to the pregnant uterus; as well as from the mammary gland to the uterus, without causing a bacteriemia.

Bang's bacillus is common in cow's milk, and virtually all occidental people consume milk or its derivatives. Children doubtless drink more milk than other persons, but they rarely contract undulant fever. According to the data of Zeller[22] the rate of undulant fever per million children from 4 to 9 years of age was 7.9 for males and 1.3 for females and from 10 to 14 it was 5.7 for males to 2.1 for females. With the advent of puberty, the incidence suddenly advanced between 15 and 19 years to 16.9 for males and 6.8 for females. Between the ages of 20 and 29 the incidence doubles for both sexes and reaches its climax in men from 30 to 39 and in women, during the decennium including the menopause, from 40 to 49. The incidence then drops rapidly for both sexes and from 60 to 74 is about the same as in childhood. Many regard the use of milk containing Bang's bacillus as the fundamental cause of undulant fever but the data indicate, quite clearly, that other factors, not yet determined, play a highly important *rôle* in its incidence.

In the horse Bang's bacillus is recognized almost exclusively in fistulous withers and poll-evil. This disease, bearing a dual name according to location, apparently is confined to the horse. I have not observed it in the mule; though perhaps it occurs in that animal. Sex is not known to play any part in the incidence of poll-evil and fistulous withers; it occurs, so far as known, with like frequency in mares and geldings. The disease is rare in young horses; I have not observed it at less than two years of age. Some influential writers hold that in those cases where Bang's bacillus is present in the abscess it is thereby proved that the bacillus is the cause of the disease. Such writers do not make it clear what it is, in fistulous withers, which they designate as the "disease." If they mean by the "disease" the basic lesions, which culminate in some cases in suppuration, they are in irreconcilable conflict with clinical observations and well established, pathological studies. Those cases of fistulous withers and poll-evil, in which Bang's bacillus is not recognizable—and they constitute the majority—can not be differentiated, clinically from those in which it is present. According to Pillers,[12] Bovette in 1861 recognized a small nematode worm as the cause of fistulous withers. Since that time numerous writers in England, France, Australia, America and other countries have recorded similar findings. So far as investigations have led, the order in the development of the disease is: (1) the in-

vasion of the ligamentum nuchae by a small thread worm; (2) calcification of the ligament as a result of the irritation of the worm; (3) abscessation. Worms are not pus producers; but when the tissues have undergone injury, the invasion by bacteria is invited. Bang's bacillus is one of an unknown number capable of causing suppuration. It then depends, upon the angle of view, whether the worm, the calcification or the suppuration, is the disease or cause of the disease. There is good logic in holding that the worm is the primary cause, the calcification the secondary, and the invading bacteria the tertiary.

Following this thought farther, a study of the outstanding contribution of Lothe[9] shows, in harmony with current belief, that the ratio of abortion was definitely higher in the positive, than in the negative cows. At the same time it was clearly shown, that the abortions recorded in the positive group, generally occurred while the cow was yet negative, or before the first test was made, so that it could not be determined, whether the aborters had been positive or negative at the time. In the data the phenomenon of abortion was used as the essential standard for computation; it was not made clear, that in some cases, other phenomena of genital disease had not been present prior to the abortion. The data of Lothe justify the suspicion, that in some of his animals, as in fistulous withers of horses, the Bang bacillus may have played a secondary *rôle*.

Laboratory workers in connection with Bang's bacillus regularly fail to record the sexual history of the experiment animals. They are secured, largely, by purchase and without available history. Commonly the inquiry, as to genital health, is limited to the agglutination test for the one bacterium. If a heifer was in bad or indifferent health as a calf, the fact is not revealed, or if a heifer required a number of copulations for the establishment of recognizable pregnancy, it is not viewed as of vital importance. The general statement is made, without the submission of important evidence, that Bang's bacillus is the chief, basic cause of sterility in cattle; but in Lothe's contribution it is recorded that 17 heifers, an unusually large number for the size of the herd, were discarded because of sterility. Apparently all these were negative.

It is commonly held that abortions, in dairy cattle during early gestation, usually are not due to Bang's bacillus. The question naturally arises, whether intrauterine disease in early pregnancy not associated with Bang's bacillus may not pave the way for later invasion by that organism, in a manner comparable to the nematode worm in fistulous withers. Conklin[2] and others have found that as gestation advances, the chemical reactions within the uterus gradually approach the optimum for the growth of Bang's bacillus; apparently owing to a decreasing oxygen supply. Cesari[1] in an outstanding contribution, makes the significant statement, that after abortion has prevailed in a herd of goats for a period of time, Bang's bacillus appears. In the ambulatory clinic of the New York State Veterinary College, Udall has observed herds of dairy cattle in which abortion and other genital diseases were severe in the absence of Bang's bacillus; but after the lapse of one to three years, that organism became recognizable. Thus evidence arises, here and there, which justifies careful study of the possibility that Bang's bacillus is sometimes a secondary invader.

The foregoing discussion is not designed to add to or to detract from the importance of Bang's bacillus. The Bang organism has received far more study than has any other associated with the pathology of reproduction, and therefore constitutes the best standard for measuring the causes of genital disease in terms of infection. Its importance as a pathogenic organism is not denied.

In all contagious diseases two factors are directly opposed—the attacking force of the contagion and the defensive powers of the individual. If the former prevail, disease follows; if the latter is supreme, health continues. The two factors vary widely in comparative strength. The vesicular venereal disease or coital exanthema of horses and cattle is each amongst the most highly contagious, and most acute of transmissible diseases of domestic animals. The acuteness and contagiousness are

in general accord with that of other contagions characterized by vesicular eruptions and caused by filterable viruses. Most infections of the genital organs of domestic animals are chronic in character and spread slowly. In my experience with dourine in the first recognized outbreak in America, the ratio of mares infected by badly diseased stallions was low.

Most contagions thus far recognized, as associated with genital pathology, possess comparatively feeble power of invasion, when opposed by highly vigorous individuals; such as the five heifers cited in the foregoing which ignored the injections of large doses of Bang's bacillus into the jugular veins, and to which was added also severe natural exposure from five aborting cows. My aim is to bring out, in bold relief, the indescribable confusion commonly existing in the pathology of reproduction. The causes for such vacillations, as have been cited, have been neither determined nor seriously studied. Bang's bacillus, in common with other contagions associated with the pathology of reproduction—sterility, abortion, dystocia, monsters, premature birth and prolonged gestation, retained afterbirth —all are governed alike by fixed laws. The need of today is to learn and comprehend those laws. A prominent worker with Bang's bacillus recently stated that it is an outlaw among contagions and does not conform to the basic principles governing transmissible diseases. He cited as evidence the occurrence of "sporadic" cases of Bang's disease, apparently meaning that scattered cases arose without the introduction of the bacillus from outside and did not tend to transmit the disease to contact animals.

Few conceptions of disease can be more dangerous than that any form of pathogenic infection exists which does not conform to well-established principles of pathology. The contention that a disease is an outlaw constitutes abject surrender of both pathologist and clinician. When a disease scorns the laws of pathology, then prevention, amelioration or cure becomes impossible. Pathology is just as obedient to natural laws as is physiology. The road to success in having health prevail over disease lies in an adequate understanding of each; not in the chance finding of a magical wand, the waving of which will transmute disease into health. When the laws of health are understood, and not until then, may the clinician hope to wage a victorious battle against disease. Wonderful cures for abortion, sterility and other pathological phenomena of reproduction have been concocted and sold to an eager public, and in the meantime genital disease flourishes. Past experiences in this field should teach veterinarians caution and modesty in their promises to clients. The clinician ever should bear in mind the far too optimistic predictions of Professor Bang when, under the exhilaration of his important discovery he declared that the cause of abortion having been discovered it could be controlled, if not by artificial immunization, at least by quarantine; since that prophecy was made, genital pathology has advanced more rapidly than during any preceding period of equal duration in the history of veterinary medicine.

The discovery of the biological cause of a disease does not necessarily lead to its cure or control. The first micro-organism to become identified as the cause of a contagious disease was the bacillus of anthrax, and anthrax is not yet under highly satisfactory control. Smallpox was the first great contagion to be brought under effective control and its cause remains unknown. The value of the recognition of the biologic cause of a contagious disease is not questioned, but it does not always solve the problem of its control; sometimes it has not even helped materially to solve it.

Artificial immunization has not yet indisputably eliminated, controlled or ameliorated a single chronic, infectious disease. The efficacy of artificial immunization against "contagious abortion" in cattle always has been controversial, although it has been practiced for more than a decade upon an enormous number of animals.

The faith of Bang and others, in quarantine measures for the control of contagious diseases should be accepted cautiously, with important reservations. Intra-herd,

intra-communal or intra-state quarantine has rarely subdued an important contagious disease of domestic animals. Tuberculosis in cattle has been eliminated from a few herds by isolation, where managed by persons of high intelligence and of infinite patience and courage; but as a community plan it has been unavoidably repudiated. Leprosy is apparently an ideal disease for efficient control by quarantine and was the first disease of history to be so attacked. It has now been fought by quarantine for 20 centuries and it is fairly safe to say that it is as common now in the tropics as it was in Palestine in the first century of the Christian era.

When all cattle positive to the agglutination test for Bang's bacillus are removed from a herd, the process commonly eliminates a variable number of animals suffering severely from genital disease. With them go some positive cows which are preeminently healthy as measured by breeding and lactation; not rarely the best breeders and milkers in the herd are positive. The process will leave in the herd animals which are negative to the Bang test but are hopelessly affected with genital disease associated with a bacterium quite as dangerous, so far as is known, as is Bang's bacillus. The negative and healthy cattle remaining in the herd will have been abundantly exposed and have remained healthy because of their intrinsic powers of defense; for that reason they will perhaps continue negative and healthy until their power of resistance is destroyed by the introduction of new forces—a diseased sire, overbreeding, famine, etc.

The United States Bureau of Animal Industry has rendered incalculable service to the nation by international quarantine against such scourges as rinderpest, contagious pleuro-pneumonia, and foot-and-mouth disease. It has received great aid in this through oceanic frontiers. Nevertheless foot-and-mouth disease has occasionally evaded the quarantine and will presumably do so again. When it does slip in it is not eradicated by quarantine but by swift slaughter. True, for a brief time, the invaded area is placed under rigid quarantine until the slaughter is completed. Quarantine is a valuable agent when applied in the right place and in a proper manner. In the experiments already cited in which I inoculated five heifers and colleagues five cows with Bang's bacilli it would have been puerile to have quarantined the five cows in order to protect the heifers; because they had ample intrinsic powers of defense; it would have been a profound error, if not downright charlatanism to have quarantined the heifers in order to protect the already diseased cows. The heifers carried absolutely no peril for the cows and no known agency could possibly have repaired the damages suffered by the cows during the previous year. Quarantine is without scientific value unless the quarantined animal carries some important contagion which may menace the health of the individual it is sought to protect.

Veterinarians have great need to tread cautiously in the field of the pathology of reproduction. There is urgent need for profound and extensive clinical observation. An important, if not the most important fact, to be determined is the character of the forces which supplied the five heifers, cited as examples, with an intrinsic power of defense which rendered them invulnerable alike to heavy artificial and natural exposure to Bang's bacillus. The same problem in principle faces the clinician at every step in the whole subject of genital disease. If the clinician can learn how the intrinsic defensive powers may be built up and blended with the pedigree, the need for quarantine, artificial immunization and medicinal remedies will probably largely vanish. Where there has been failure to produce such powers of resistance, the amelioration or cure of the disease may be undertaken far more intelligently.

In the succeeding addresses, clinical observations and studies will be presented in an effort to illustrate some of the basic principles, by means of which the natural defenses against genital disease may be built up and maintained. It will be held that the building up and perpetuating of such intrinsic defenses should be the primary consideration of the clinician, and that it is not until this has failed, that artificial protection or cure requires attention.

Lecture No. 2.

The Influence of the Health of the Newborn Animal Upon Its Ultimate Breeding Efficiency

THE menace to health begins at the commencement of life. It is quite certain that more fertilized ova, embryos and small fetuses perish and disappear unseen than are born and aborted combined. Non-mortal diseases of the embryo often lead to the formation of monsters, or lesser aberrations, which lower or destroy the value of the animal. Keller[7] observes that toy bulldogs commonly have slight hydrocephalus which has become a trait of the breed through artificial selection. Hydrocephalus constantly tends to interrupt the orderly development of the other organs of the body, especially of the genital organs. These breeds are of low fertility. In a group of monsters recently described,[20] I have pointed out that in them, regardless of the location of the basic disease, aberrations of the genital organs were the rule.

The frequency of abortion indicates the abundance of utero-fetal disease. It would be folly to say that all diseased fetuses are aborted. Those not aborted but registered clinically as premature birth, stillbirth, prolonged gestation and otherwise are just as definitely diseased are those which are aborted and collectively they outnumber the abortions. Healthy gestation is highly uniform in its duration. When pregnancy is abbreviated or prolonged, it is conclusive evidence of fetal disease. The young are born either evidently diseased or highly sensitive to the stresses incident to birth, and are markedly liable to the diseases of the newborn. The damage does not end there. Von Ottingen[14] has well shown, that foals carried overtime do not become highly valuable horses—the fetal disease has left an indelible mark. Some dairymen regularly destroy definitely premature calves, because their experience has taught them that, as a rule, such calves do not become valuable dairy animals.

A young animal may be apparently healthy at birth but quickly become diseased. According to its severity the disease may cause a permanent general weakness; the normal development of the reproductive organs may be repressed and leave them weak, or various bacteria or other form of contagion may acquire a permanent habitat ready to cause disease at breeding time. The latter is well illustrated by the granular or nodular venereal disease which is universal in dairy, and common in beef calves as well as in sheep and swine. It frequently causes a very severe vulvitis in dairy heifers following the first coitus, the vulvar mucosa being intensely inflamed, covered with muco-pus, highly sensitive and bleeding at touch. The prepuce of young bulls occasionally becomes so severely inflamed that hemorrhage follows coitus and sometimes causes phimosis. The symptoms decrease in intensity with age.

Dairy calves are the most unhealthy of all young domestic animals. The mortality is high, and those which survive commonly suffer from diarrhea, pneumonia, arthritis, chronic indigestion with pasty feces, emaciation, pot-belly and dry, rough, dirty coat. When five to six months old they apparently regain their health.

When discussing the pathology of reproduction in perspective, the observation was made (p. 262) that reproduction

is a luxus function and is not physiologically undertaken by mammals until the individual has acquired a surplus of nutritive energy in excess of its needs for the maintenance of its physical life. It has been stated above that in monsters and lesser embryonic aberrations there is a preëminent tendency toward the arrest or aberration of the genital organs of both sexes, regardless of the location of the basic disease of the embryo. So in harmony with the general principle of reproduction as a luxus function, the constructive powers of the embryo are preferentially devoted to the formation of the organs essential to physical life, and any deficiency of nutritive energy is likely to be expressed in the form of imperfect development of the genital system. Weak fetuses accordingly manifest a marked tendency toward arrest in the growth of the organs of reproduction. Thus in the new-born male—the male sex is dominant amongst aborts and weak new-born—cryptorchidy is more common than arrests in the growth of systems of organs essential to life. After birth there is a period in all mammals during which the reproductive system is functionless. In conformity with the general principles mentioned, the nutritive demands of the organs essential to life continue to take precedence over those of reproduction. It should therefore be logically expected, that if the nutritive supply of the dairy calf is severely depressed by faulty artificial feeding, accompanied by serious digestive disturbances, the ideal development of the reproductive system would be correspondingly menaced.

As a rule when the dairy heifer is six or seven months old she begins to ovulate and may conceive if opportunity occurs. Her genital system has been hurriedly developed and its general proportions and ultimate texture fixed. Each part of the system may grow with the age of the animal, but unless the organs are up to normal scale, compared with functional activity when ovulation begins, there is ample evidence to show, that the genital system will not reach full physiological development, but the heifer will arrive at breeding age with juvenile sexual organs, incapable of satisfactory reproduction. They are sexually weak; estrum is often irregular and they sometimes menstruate excessively. Many of them conceive tardily, or not at all. In some herds, a given crop of heifers, show a very high ratio of incurable sterility. Pregnancy is unsafe; many abort or expel dead calves at term; dystocia is common; the fetuses are preponderantly males, and the ratio of twins is excessive. The calves are largely born at less than 280 days; are small, sensitive, of low resistance and suffer from diarrhea. The heifers largely retain their afterbirths; uterine torsion and prolapse are not rare, and any or all things may occur except typical physiological birth.

The pathological phenomena vary in different herds and at different times. Sometimes abortion dominates, associated with retained afterbirth and subsequent sterility. This is well illustrated in Table I. The group consists of 18 dairy heifers comprising four breeds. The calves of the herd had been grown, for a number

Outdoor freedom with adequate natural forage, advances reproductive vigor

of years, under "pesthouse" conditions, in a poorly lighted and ill-ventilated basement; always swarming with flies. The stalls could not be kept clean. The calves regularly suffered from severe diarrhea, with a high incidence of pneumonia and death. Arriving at breeding age, there was year after year an average abortion rate of about 50% in the first pregnancy, after which sterility was common. The herd was not reliably self sustaining.

It will be observed that among 37 births there were 3 pairs of twins, or a ratio of 8:100. The plan of calf growing was modified and the abortion rate in first pregnancy dropped below 10%.

TABLE I

Observations Upon a Group of 18 Heifers Bred to First Calve in 1912
A=abortion. B=bull. H=heifer. S=sterile. X=premature birth.

No.	Born	1912	1913	1914	1915	1916	
1	12- 6-09						Destroyed account gangrene of uterus and emphysema of fetus.
2	10- 6-09	A					Died of metritis.
3	2-24-11	A					Slaughtered, sterile.
4	10-30-10	A					Slaughtered, sterile.
5	9- 6-10	A	A	S			Slaughtered, sterile.
6	9-29-10	X B	S	B H	S	B	Slaughtered, sterile.
7	11- 6-10	A	B B				Died of metritis.
8	4-26-11	H					Slaughtered, sterile.
9	7-20-10	B					Retained afterbirth, sold, inefficient.
10	1- 1-11	B	B				Sold, gangrene of udder.
11	2- 5-11	A	B	B	B		Sold, inefficient.
12	9-22-10	A	H	B			Died, indigestion.
13	10- 5-10	H	B	H	B		Sold.
14	10-20-10	H	S	B	B	B	
15	10-18-10	B	H*	S	B B		
16	10- 5-10	A	B	B	B	H	
17	10- 5-10	A	H	B			
18	12- 9-10	A	H	H*	H	B	* Died.
Heifer calves		3	4	3	1	1	Total 12
Bull calves		4	6	6	6	3	Total 25
Abortions		11	1				Total 12

Summary, Eighteen Original Heifers

Died	4
Slaughtered sterile	5
Sold	4
On hand, 1916	5
Heifers grown to breeding age	8
Heifers not of breeding age	2

In Table II the problem is illustrated from a slightly different angle. In a dairy of 500 milking cows, the mortality of young calves had been very high for a number of years. When the heifer calves reached breeding age the average abortion rate exceeded 40%; associated pathological phenomena were excessive, and the calving heifers milked badly. Tuberculosis was common in the herd and as test for abortion was made. The animals were selected from two herds upon an intimate personal knowledge of the breeding health prevalent in the establishments. Seventeen heifers were selected from a herd composed of animals having thoroughly respectable, but not fashionable pedigrees in which it was known that the sexual health was exceptionally good and the young calves unusually healthy.

TABLE II

The breeding efficiency during the first breeding year of heifers, reared before and after modification of their feeding when calves

Group	Period Covered	Heifer Calves Born	Died of Scours and Pneumonia	Died of Other Causes	Sold for Veal	Pregnant or Below Breeding Age	Number in Which Pregnancy Has Terminated	Calved	Aborted
I	1909-1912	593	184	113	118	...	170	95	75
	40 months	...	31%	19%	19.9%	...	...	55.9%	44.1%
II	1912-1916	904	203	71	...	402	225	203	22
	50 months	...	22.4%	8%	...	...	...	90.2%	9.8%

a means of combatting it, after discarding tuberculin reactors, the milk for the calves was pasteurized. The accuracy of pasteurization was doubtful; unless fed quickly after pasteurization, the milk underwent fetid decomposition. Under the environment, boiling of the milk was advised. The calves were continued in the same buildings and after the close of milk-feeding were grazed in the same pastures and in winter kept in the same stables and in general had care identical with that of the first group. Upon reaching breeding age they were bred to virtually the same bulls.

In Group I, mastitis was common in first lactation; in Group II it was rare.

The influence of the health of the heifer calf upon her future breeding efficiency is still better illustrated in Tables III and IV.

In 1920 I was asked to purchase 20 Holstein heifers and five bulls as a foundation for a dairy herd in the tropics. It was requested that the animals be free from tuberculosis and contagious abortion. Neither bacteriological, nor serological In Table III they constitute Group A. The other three heifers were selected from a herd composed of animals of highly fashionable pedigree. The sexual health of the herd was only fair.

In 1921 thirty-five additional heifers were purchased, which with the three fashionably bred animals already mentioned, constituted Group B in Table III. The 35 heifers came from 7 herds scattered from Ohio to North Dakota. So far as known they were selected upon the basis of pedigree and physical appearance. I was familiar with breeding conditions of the herds from which a majority of the 35 animals were selected and knew that at best the sexual health could be classed as fair only, and that in general the young calves were unhealthy.

Groups A and B have been handled throughout as a single herd. They have not been stabled. They have occupied a common paddock and necessarily have shared identical forage. They have been bred to the same bulls. The nine large herds from which the heifers were selected, many, if not most of which suf-

fered seriously from genital disease, doubtless harbored in abundance every form of contagion commonly associated with abortion and other pathological phenomena of reproduction. Most of the heifers were pregnant, some in early, others in late gestation. Some had not been bred. Ample opportunity was thus provided for carrying into the new herd any common genital infection capable of existence in any stage of gestation or in non-pregnant heifers. Important evidences of genital disease appeared in Group B while in transit. There has been every opportunity, year after year, since 1921, for the thorough dissemination of any contagion or contagions throughout the herd. Genital disease has taken a heavy toll from Group B, while Group A has calmly adhered to good genital health and has made a wonderfully high record for fertility until they had reached ten to fourteen years of age when old age, combined with severe drouth and innutritious forage, lowered their vitality, and some abortions occurred. Eight of the 17 still live. The group has now produced an average of 8.2 viable calves

TABLE III

Breeding Statistics upon Three Groups of Cows on the Same Ranch

Group	No. Females	Viable Calves	Av. Viable Calves per Cow	Non-viable Young				Percent of All Pregnancies	Twins
				First Pregnancy		Pluripara			
				No.	Percent	No.	Percent		
A	17	139	8.2	0	0	7	4.8	4.8	1 = 0.72:100
B	38	212	5.58	8	21.7	30	14.1	15.2	8 = 3.2:100
C	196[1]	346	1.8	72	36.7	62	21.8	27.9	6 = 1.3:100

[1]—32 females in Group C had not yet calved or had not been known to have aborted by Nov. 30, 1931

TABLE IV

Group C

Year of Birth	No.	First Preg. not Terminated	Calved or Aborted	Total Preg.	Viable Calves	Viable Calves per Cow	Non-viable Young					Rain
							First Preg.	%	Later Preg.	%	Total %	
1920	5	0	5	26	18	3.6	3	60	5	24.0	31	14.89
1921	9	0	9	63	55	6.1	1	11	7	13.0	12.7	21.82
1922	14	0	14	60	50	3.6	0	0	10	21.0	16.7	26.98
1923	19	0	19	71	59	3.1	3	15.8	9	17.3	16.9	40.48
1924	33	0	33	92	69	2.1	8	27.6	15	23.8	25.0	20.67
1925	26	0	26	50	31	1.2	12	46.3	7	29.2	38.0	13.27
1926	41	0	41	61	35	0.85	19	46.3	7	35.0	42.6	12.16
1927	33	6	27	35	16	0.48	17	63.0	2	11.1	54.3	31.49
1928	48	26	22	22	13	0.27	9	40.9	0	0	40.9	26.07
	228	32	196	480	346	1.8	72	36.7	62	21.8	27.9	23.09

each. Should the 8 surviving cows produce 14 additional calves, which appears quite probable, the average calves per cow will exceed nine. Naturally Group A has far excelled Group B in milk production. A detailed study of the herd reveals no plausible explanation for the differences in fertility between the two groups except that the cows in Group A had acquired as young calves a highly valuable, intrinsic defensive power. The pathological phenomena consisted largely of stillbirths, with severe dystocia, at or near term, with numbers of abortions and retained afterbirths.

The female progeny, Table IV and Group C in Table III, were kept in a common enclosure and fed and handled alike. Upon reaching breeding age they were placed in the common herd with Groups A and B. During the nine years from 1920 to 1928 inclusive 228 heifers had been grown and bred so that, if genitally healthy, they should have calved prior to December 1, 1931. In Table IV it is indicated that 32 of these had not been recognizably pregnant. The conditions were such that early abortions might largely escape detection.

In the early history of the herd, the total calves per annum was small, and they were healthier than in later years when the progeny of the original females had begun breeding. The calves were fed in a group, devoid of individual control or isolation. They had an abundance of whole milk for three months and plenty of skimmed milk for an additional three months. Much milk was spilled at the feeding place and the soil became polluted and stinking. Horses were allowed in the calf paddock and the calves ate horse feces. In dry periods, which were frequent, succulent grass was scarce or wanting and the calves ate freely of dry grass and weeds. Diarrhea was common and pneumonia not very rare. The mortality was low. The survivors suffered much from chronic diarrhea, adhesive feces, cough, pot-belly, rough hair and emaciation. They rallied at six to eight months and grew fairly well but were generally undersized, pot-bellied and notably narrow and peaked behind.

When they arrived at breeding age, they conceived very tardily; apparently many conceptions ended early and unobserved; the recognized pregnancies were unsafe, abortion was common; dystocia the dominant phenomenon, with a very high ratio of stillbirths or dead calves. The entire genital system was markedly juvenile, the ovaries small, the uterus and vagina subnormal in dimensions and in defensive power. The outstanding phenomenon in the defective development was an extremely narrow vulva. Heifers three years old and upwards, weighing 800 to 1,000 pounds and more, and six months pregnant had vulvae which would not admit the introduction of more than two or three fingers without the application of definite force. Several heifers were killed outright by the forcible extraction of the fetus. In two cases the forcible extraction of dead fetuses caused complete perineal rupture from which they survived. Each again conceived, followed in one by the expulsion of a dead fetus, in the other by a viable calf.

I applied traction as gently and carefully as possible and by working patiently for two to four hours was able to extract the fetuses without causing extensive lacerations, but the long continued and severe compression of the vulvo-vaginal mucosa inevitably led, in many cases, to very severe gangrenous vaginitis with a tendency to vaginal atresia which required constant attention for weeks. In the severe dystocias the fetuses were usually bulls; frequently presented posteriorly. Often the fetus was alive at the beginning of labor but succumbed during, or immediately after extraction. Dropsy of the amnion and allanotois was very common; hydrocephalus with deformed extremities was not rare. Retained afterbirth and metritis was the rule. No method of delivery could be devised which might evade the disaster: an unshakable foundation for disaster had existed

throughout gestation. The heifers, as young calves, had failed to properly develop the genital system. The milk-feeding period of six months having passed without proper sexual development, and ovulation having set in, the subnormal development of the reproductive system became permanently fixed both in dimensions, and in defensive power against contagions.

The significance of these observations rests upon the large number of animals involved, all reared, handled and bred alike, followed by highly prevalent pathological phenomena of relatively uniform character.

Identical phenomena are observed by every clinician with experience in dairy practice; but the cases are solitary and their basic significance is lost. Sterile, dairy heifers are repeatedly encountered with vulvae too small to admit the operator's hand, and much labor is devoted to mechanical dilation under the assumption, that if the dilation succeeds, the way will be open for overcoming the sterility. The assumption is generally erroneous; the basic cause of the sterility lying far deeper. The mechanical dilation of the vulva does not eliminate hypoplasia of the whole reproductive system.

Some such heifers conceive; gestation continues to term, and the clinician is called to overcome dystocia, dependent upon a very narrow vulva. The basic character of the dystocia is variously interpreted by the clinician dealing with isolated cases. Sometimes it is believed the vulva is too small, at others, that the calf is too large. Any calf is comparatively too large in such a heifer; the heifer is not big enough anatomically or physiologically to give birth to an object which might be justly regarded as a calf. One of the heifers in Table IV was in dystocia from abortion. The heifer would weigh about 700 to 800 lbs. The abort was the size of an ordinary cat. I worked hard for an hour to pass my hand through the vulva. The abort lay free in the cervix but I could not extract it with my hand because the vulva would not permit the passage of the head along with my hand, and I was compelled to pass forceps along my hand, grasp the head, withdraw my hand and then extract the fetus with forceps. With much after-care the vulva was moderately dilated. She conceived again and was again in dystocia, the fetus was dead and the heifer failed to lactate.

The cattle represented in Tables III and IV were wholly dependent upon grazing except for the milk feeding to young calves and limited grain allowance to cows in milk. The quantity and quality of forage is dependent upon the rainfall, which is regularly recorded day by day to the one-hundredth of an inch. The total for each year is indicated in Table IV. At times severe drouth prevails for months in succession and the forage is dry and woody. This lowers the strength of the pregnant cows, the calves are born less vigorous and are compelled to eat dead grass and weeds. Sometimes the precipitation is low throughout the year, as in 1925-1926. The general effect of such drouth is traceable in the fertility of the herd and markedly in the health of the calves, as well as in their fertility when reaching breeding age.

The causes of sexual disease rarely, if ever, act singly and the force of one cause is regularly modified by other factors at work. Thus in Table IV, there is a wide variation in the behavior of the 1920 and 1921 heifers. The numbers involved are small and the implications need be accepted with caution. They were apparently cared for alike as young calves. Dairy cattle are amongst the most sensitive of domestic animals. Intense breeding with heavy lactation places upon them an inordinate sexual load. Pregnant females withstand transportation and change of environment badly, and show a definite tendency to abort or calve prematurely from the disturbance. The dams of the five 1920 heifers were shipped in advanced pregnancy 3,000 miles by rail, 2,000 miles by boat and finally transferred

to a small boat for a normal sail of 14 hours. The small boat ran into an unusually severe storm and the heifers were tossed about unmercifully for 32 hours. The decks were awash, their halters were broken, and it was impossible to either feed or water them. Ordinarily a high rate of abortion would have followed. They landed in July, five of which were to give birth to the 1920 group of heifer calves within three to five months. Perhaps the severe physical and psychic strain through which the pregnant heifers passed was reflected in the breeding health of the calves carried in utero. In the 1921 group of heifers their dams had had a longer period for recuperation from their journey before the calves were born. Some of the calves were of the second crop, the result of breeding after arrival in the new environment.

A second, and more important element affecting the relative fertility of the 1920 and 1921 heifers was the question of precipitation and consequent state of forage. The heifers, greatly fatigued from their long journey, had arrived during a severe drouth. This lowered the nutritive supply; depressing the vigor of the pregnant heifers and of their intrauterine young. The calves, born less vigorous because of the drouth, were denied succulent forage. At the close of 1920 heavy rains came, and the rainfall for 1921 was good; the pregnant heifers were knee deep in lush grass and the new-born calves had ideal forage from the first.

The contrast between the two groups is sharp. The 1920 group show an average of 3.6 viable calves per cow: 4 of the 5 cows have succumbed to sexual disease. As a group they are apparently destined to fall below 5 calves each. The 1921 group has produced 6.1 calves each; surpassing Group B, which are about 2 years older. Almost all are living, are in apparently good general and sexual health, and should reach an average calf production of 9 to 10.

In harmony with current thought, many would attribute the destructive genital disease primarily to contagion. That contagion was present in abundance is undeniable. The abortions, the metritis, retained fetal membranes, gangrenous vaginitis and the endless list of pathological phenomena would be unthinkable in the absence of bacteria. The vital question to be determined is whether the contagion was basic and capable of producing destructive disease in animals not profoundly depressed by methods of feeding and handling, or whether the contagion was of low invasive power and became destructive only in weak, defenseless animals. Perhaps it would be justifiable to ask whether the contagion was primary or secondary. If it were a primary contagion of ample invasive power it should have definitely involved in the maelstrom the females in Group A, Table III and the 1921 crop of heifers in Table IV. They mingled freely year in and year out. The contagion could not, by any conceivable means have invaded the herd from without. No animal of either sex has been added to the herd since 1921. Surrounding the herd on every side is a herd of 25,000 Herefords, with thousands of breeding females separated from the dairy herd by wire fences. The Herefords are in a very high state of sexual health; any extrinsic contagion would need pass through this healthy cordon five miles deep at its narrowest point. The evidence all pointed definitely to intrinsic, intra-herd causes.

Careful study indicated with great emphasis that the most important and basic cause lay in the errors in the handling of young calves. After six months of constant study, with trials and failures of various plans, a sufficient number of portable calf pens were constructed to accommodate each calf up to one month of age. The pens were arranged in a row at one end of a field and were moved daily to fresh ground, from which all dead grass, weeds and rubbish had been carefully removed. When the line of pens had reached the farther end of the enclosure, sun, wind and rain had effec-

tively cleansed the turf at the point of beginning, to which the pens were removed. The plan exposed to full view the feces of each calf and made it easy at all times to determine the state of digestion. It prevented the calves from eating or swallowing any form of rubbish or indigestable substances, and prevented the dangerous habit of sucking each other. The portable pens were supplied with a detachable cover sufficient in extent to protect from rain or hot sun. The cover had attached to it a drop side which could be dropped upon the windward side and protect the calf against cold wind and rain. When one month old they were turned together in a paddock with abundant grass. They were fed whole milk in stanchions on a concrete platform, each calf having a separate pail. After taking their milk they were fed a little dry grain and kept confined in the stanchions until their muzzles were dry and free from milk. They did not suck each other. The stanchion platform was washed with hose after each feeding and the gates to the stanchion enclosure closed so that the calves could not enter until the next feeding time.

The formula for feeding was as follows: The calf was permitted to remain with the cow for 12 to 24 hours, and then placed in a portable pen and allowed no food, if apparently well, for at least 12 hours. It was then fed one pound each of milk and lime water in which 4 oz. castor oil had been emulsified. The calf does not object to the castor oil but readily eats it with the milk. The ration of one pound each of milk and limewater, without the castor oil, was continued twice daily until the calf was 6 or 7 days old. If at that age the calf was well the limewater was discontinued and the amount of milk cautiously increased to a satisfactory ration. If at any time diarrhea appeared, or the feces were streaked with blood, or were fetid, or sticky, or other signs of indigestion were present, the castor oil was repeated and the ration of one pound each of milk and limewater resumed.

The effects were very striking. Indigestion was effectively controlled, the calves were vigorous and playful, their coats retained their original lustre, they were not pot-bellied and in spite of the limited ration they grew well and were at no time gaunt. The ration cost less per day, the limewater and castor oil included, than the milk ration ordinarily recommended. At six months they were much larger, and of far better conformation, than under the old plan. The peaked rump had disappeared and so far as could be determined they were in ideal health. The first of these are now two years old and ready to breed. I look forward with great confidence to satisfactory breeding and their ability to carry the burden of reproduction with the same efficiency as Group A and the 1921 heifers of Group C.*

*Since the foregoing was written an authentic report is at hand that all the heifers born during the first nine months under the revised plan of feeding had been bred. Almost all conceived after a single service and none required more than two services.

Communal grazing, Madras, India

Lecture No. 3.

The Nutritive Supply and the Breeding Power

The Influence of the Food Supply Upon Breeding Age

If an immature female conceives she must first maintain her physical life and continue in a measure her growth, before she can safely undertake the burden of efficient nourishment of her intrauterine young. If a dairy heifer is bred at fifteen months, when perhaps less than half the size of her dam, she immediately faces the triple load of her own growth, the maintenance of her life and the life and growth of her intrauterine young. The load is not vacated at birth. Profound changes have occurred in her uterus during pregnancy. If she is to retain her sexual health her uterus and other genital organs must be restored promptly to the pre-pregnant state. In nature she must secrete sufficient milk for the needs of her calf; in dairying she is asked to yield a profitable milk supply. Fatigued from the burden of pregnancy while immature; her energies taxed to capacity in the repairs after calving and in heavy lactation, she is not infrequently rebred within 40 to 60 days; although still immature, and in the natural state not yet ready to conceive for the first time. She then commonly falters if she has not previously experienced disaster. Her milk yield diminishes abruptly and her second pregnancy is menaced.

At the opposite extreme is the observation of du Toit[3] that the native cattle of Algeria, accustomed to a very poor veld, commonly first calve at about seven years. The gradations between these extremes are created through artificial selection and the food supply. Common heifers living upon an ordinary range, where the forage is at no time abundant and at some seasons definitely scarce, commonly ovulate and first come in estrum at two years, while the artificially selected and highly-fed dairy heifers are commonly in heat at six months. The five dairy heifers mentioned on page 265, which ignored artificial and natural exposure to Bang's bacillus had been grown slowly. When about two years old, and it was desired to breed them preparatory to inoculation, it was discovered they were not coming in heat and hence could not be bred. They were being fed sparingly upon timothy hay of indifferent quality. The addition of a light grain ration promptly overcame the difficulty and conception ensued. The heifers had not been starving upon the hay ration, but there was no surplus energy upon which to undertake reproduction.

Both growth and ovulation are advanced greatly in highly-bred and highly-fed, dairy calves; the ovulation apparently outruns physical development. The dairyman is naturally desirous to place his heifers upon a profitable basis as early as possible. He is supported in this by prominent and able investigators, who present data indicating that a heifer may be safely and profitably bred to calve at two years. The researches commonly involve but a short period, and do not follow the animals to the close of breeding life. In this way a good showing may be made, although completeness of the investigation may well be challenged. The belief has become current, that unless heifers are bred early, they tend to become sterile or to conceive with difficulty and are poor milkers. The assumption is apparently based upon a confusion of facts. If a heifer conceives with difficulty, and only after several breedings, whether first bred at 12, 24 or 36 months,

it is not probable that she will become a valuable dairy cow. Her career is blighted because she was sexually unsound when first served. It has not been clearly shown that a sexually healthy heifer is seriously damaged by holding her out of breeding until 24 to 30 months of age.

The 17 heifers constituting Group A in Table III, page 275, were unusually uniform in pedigree, type, health and vigor. The terminations of their first pregnancies ranged between 1.96 and 3.12 years. Two had passed three years at first calving. Both are living and are 14.3 and 14.2 years old respectively. One has produced 11 viable calves, the highest in the group, the other is one of three which have produced 10 viable calves each. Eight heifers calved at less than 2.25 years and have averaged 7.75 calves each. Nine had passed 2.25 years at first calving and have averaged 8.44 calves each. In the early-calving group, 32.5% survive; in the late group 55.5%, a superiority of 70%. The ratio of aborts and non-viable calves in the younger group is 7.5 as compared with 3.8% in the older. The records show that three heifers required more than one service for conception. The delay caused all three to pass from the younger into the older group; that is had they conceived at first service they would have been in the younger group. If they be shifted to the younger group, important changes occur in the computation. The number of viable calves per cow in the younger group drops to 7.73 and advances in the older group to 8.83. In the younger group the mortality is 63.6%, in the older 33.3%. The aborts and non-viable calves advance in the younger group to 8.2% and recede in the older to 1.9%. As measured by the production of viable calves, by the ratio of abortions and non-viable calves, and by the longevity of the cows, the superiority of those heifers bred to calve after 2.25 years is definite and authentic. The heifers of the entire group had been well fed and were healthy throughout their lives so that for their ages they all were well developed. The inferior showing of the younger portion can not be attributed to want of maturity for their age; but must be regarded as strong evidence, that in highly vigorous and well grown heifers, breeding them to first calve at less than 2.25 years of age proved injurious and uneconomical. Extensive data in this field are not available. Careful study of this little group of seventeen indicates that the optimum date for heifers of their type to first calve, whether considered from the immediate economy in dairying, or from the standpoint of the upbuilding of the dairy and the breed, is not far from three years.

Abortion is the most commonly accepted standard for measuring the intensity of sexual pathology in domestic animals. In dairy cattle, where genital disease is the most destructive, it is by far most prevalent in first pregnancy. When discussing the influence of the health of the young calf, (page 271), it was held, that if a heifer calf were unhealthy during its milk-feeding period, its first pregnancy would be seriously endangered thereby, and that the fertility and longevity of the animal would be lowered. The foregoing studies of Group A bring into view the further highly important element of the age at which the heifer is first bred. This factor presumably acts alike upon heifers whether healthy or diseased during the milk-feeding period. The principle apparently applies alike to all domestic animals. In most species of domestic mammals nature bars premature conception through non-ovulation until the young animal is well matured. The two notable exceptions are horses and cattle, in which artificial selection, warm housing in winter and abundant food have served to nullify nature's law in certain breeds and families and cause ovulation to occur far in advance of maturity. A client inadvertently permitted a group of yearling Percheron fillies to become pregnant; all aborted at less than two years of age. I attended several of them be-

cause of the complication of dystocia. Accidental conception in dairy heifers at five to eight months occurs now and then and is commonly tantamount to ruin.

While abortion and other pathological phenomena of reproduction are conspicuously most prevalent in first pregnancy in dairy heifers, this rule is vacated when heifer calves are healthfully grown and not bred while too immature. This is well illustrated by the eight aborts and non-viable calves in the 17 heifers. Their distribution according to the number of pregnancy was as follows:

Second pregnancy	1
Sixth pregnancy	1
Seventh pregnancy	1
Eighth pregnancy	2
Ninth pregnancy	3

Seven animals were involved, one having aborted the eighth and ninth pregnancies. While droughts and other factors have played a part, the decreasing energy of old age is clearly the most important. The entire group has been heavily bred. Many of the cows repeatedly bore two calves at less intervals than 365 days, sometimes at little more than 300 days. They stood the strain well, but at last began to falter.

Observations by McCampbell[10] indicate that range Hereford heifers, without having had a substantial grain ration and bred to calve at two years are seriously damaged. The calf crop was 30% below that of three-year-olds and 30% of the heifers early became non-breeders.

The influence of nutrition begins with the fertilized egg and ends only with the close of reproductive life. The nutrition may be defective in various ways. Sometimes there occurs a definite malnutrition, in which nutritive elements may be present in sufficient amount but the food is contaminated with injurious substances or is given to the animal under such conditions that the food elements reach the tissues associated with dangerous materials. In the endometritis of pregnancy, so prevalent in dairy cows, the nutritive elements which reach the gravid uterus through the uterine arteries may largely fail to pass the barrier of disease in the placenta and that which does pass inevitably carries contaminating elements from the diseased tissues. The effects of these are abundantly registered in the frequent fetal diarrhea in diseased dairy cows, the meconium being clearly recognizable in the amniotic fluid. The disease disturbs development, causes abortion and premature birth, and the latter leaves in its wake a weakness which imperils future breeding health.

In the herd comprised in Tables III and IV the cattle are primarily and almost wholly dependent upon forage. The ranch is not stocked to capacity; an abundant reserve of forage is assured always. When droughts come, the most succulent and protein-rich forage, like blue grass, the clovers and vetches, etc., disappear and Bermuda grass takes precedence. It becomes dry and woody, but there are no material indications of decomposition. It is apparently good forage, at least as measured by the condition of animals not burdened by breeding or old age; they are fat and show every sign of excellent nutrition. But pregnant cows, cows in milk and aged animals show the strain. Apparently the woody forage is too difficult of digestion to enable the handicapped animal to maintain adequate nutrition. Hence periods of drought are marked by depressions in the rate of reproduction, with abortion as one of the phenomena. The abortion climax comes at the end of the drought when cold rains borne on strong winds chill the pregnant animals already depressed by the dependence upon forage of low nutritive value. As soon as the rains have produced abundant succulent forage the abortions disappear, the conception rate advances and the milk yield increases. These forces are seen less clearly in dairy cattle of the temperate zone, regularly stabled in winter. Their fertility declines as winter advances, but when spring comes and cows and heifers, long sterile, have access to succulent grass, their fertility rises.

Famine is inseparably linked with pestilence. In most agricultural districts with reliable rainfall, famine is a stranger. In the great cattle ranges of the western United States, where cattlemen habitually stock the ranges to capacity in years when rainfall is normal, the cattle are brought face to face with famine when drought comes, and there is nothing more certain in a range country than occasional drought. Then pestilence follows. There are always sufficient forms of bacteria or other types of parasitic life to create havoc when animals are depressed greatly by famine. There is no need for the importation of contagion from without. The pestilence can not be stayed by isolation, quarantine, vaccination or medication. A few years ago severe drought brought famine in an extensive range area on the Pacific coast. An acquaintance went into this area and purchased cheaply eight hundred Hereford heifers; had the seller breed them, and then shipped them to a range with ample forage. The 800 heifers produced 35 calves! Parts of Montana have suffered severely for two or three years from drought. The cattlemen had stocked the range to the limit of its capacity under normal precipitation. What forage existed at the beginning of the drought was good. It is not a question of damaged food but one of the absence of forage. The common cattlemen have no store of cured or preserved foods and no funds with which to import food. Abortion became rather conspicuous early in the drought and there was talk of the application of the agglutination test in order to determine if the offender were Bang's bacillus. But as the drought continued abortion in the starving cattle became so common that each owner was made fully aware that his herd was aborting abundantly and he ceased to worry about getting contagious abortion from his neighbor. My informant, a progressive breeder of pure-bred Herefords, had sufficient food of good quality in store; he does not dread the introduction of abortion from his neighbors so long as his food lasts. It may aptly be termed "famine abortion." Many adult animals are dying of want and with the prevailing abortion the numbers of cattle in the area will become reduced to the capacity of the range and, when rains come, they will breed and thrive for awhile, until the cattlemen again heavily stock the range and the next famine arrives. This is of course a provision of nature for the perpetuation of the species. If the dam's life were sacrificed for the young it too would succumb. If by sacrificing the young the dam's life can be saved she can continue the species when the famine is passed. The faculty is inherent and without it the species probably would not have survived the long series of famines that must have occurred in its history and would be numbered among the extinct species of by-gone ages.

The Rest Interval Between Pregnancies

The interval elapsing between the close of a pregnancy and the resumption of ovulation varies widely according to species. The mare is regularly in estrum at six to ten days, most commonly on the ninth, postpartum. In the cow the corpus luteum is regularly present at calving time and she does not ovulate until the body has atrophied, a function which is profoundly affected by the health of the genital system. It has been noted previously that the occurrence of ovulation and heat have been changed profoundly in horses and cattle through artificial selection, food and housing, and that as a rule heifers and fillies ovulate and come in heat long before they have reached a stage of development consistent with safe pregnancy and birth. In these two species also estrum occurs in a large proportion of females after an interval following the termination of pregnancy insufficient to permit the reproductive system to fully recover its pre-pregnant state. Little accurate study has been devoted to the question of how long a puerperal mare or cow had best be held out of breeding in behalf of her

sexual health. It is decided largely by tradition.

Practically all horse breeders and writers upon horse breeding are unanimous in the belief that a mare should be bred upon the ninth day after foaling. Little evidence is available in support of this view. The very limited data I have been able to secure upon this point indicates that a mare which conceives on the ninth day is three to four times as liable to abort as a mare bred at a later date. There is confusion here because most mares not bred on the ninth day are held back because of obvious genital disease. According to my observations, in a Thoroughbred stud in which genital disease was high, most mares showed definite endometritis on the ninth day with profuse genital discharge associated with diarrhea of the foal. Healthy mares largely conceive if bred on the ninth day, but when breeding is forced, and famous stallions are heavily used, the mares largely become unsound genitally. According to my observations such mares conceive more readily and the pregnancy is safer if bred at the second estrum.

Von Oettingen[14] observes that Thoroughbred foals born at 320 days or less have an excellent prospect for developing into valuable animals, while those carried over 345 days are almost never highly efficient. According to my observations foals carried 365 days or over are only rarely viable, although commonly alive when expelled. It is fairly safe to assume that careful observation would show that prolonged gestation, like abortion, occurs in a far higher ratio in mares conceiving on the ninth day, in spite of the fact that it is only the healthiest mares that become pregnant at the first heat.

Under the influence of tradition the horsebreeder raises two, apparently formidable, objections to not breeding the mare on the ninth day. He believes that the mare does not promptly come in estrum again and that when she does so she does not so readily conceive. The belief is apparently based upon the behavior of those mares so shockingly diseased at the ninth day to make breeding unthinkable. Badly diseased mares are not regularly in estrum and do not readily conceive. The other objection is that if the second estrum is awaited the mare will not again foal within a calendar year. The ground is poorly taken. Some of the most severely diseased mares which retain a measure of power to breed, regularly carry their foals beyond 365 days and thus exclude all possibility of again foaling within a calendar year. Conception on the ninth day, before the genital system has recovered from the prior gestation, may very well lead to later foaling than had the mare been held out of breeding until the 30th day and full recovery been permitted. The law would then be that the uterus being healthier, the development of the fetus is more rapid, the gestation shorter, the foal larger and more vigorous and the mare has borne the load with less injury.

In dairy cows, where metritis and retained afterbirth are so common in their milder forms, that they are largely regarded as normal, involution of the uterus is retarded greatly; the duration of time required for a complete restoration of the genital system to the physiological pre-pregnant state is much prolonged. The cows depicted in Table III had suffered generally and severely from metritis. With a view to an improvement of the breeding health, it was decided in 1930 to allow each cow a sexual rest of at least 6 months, after the termination of a pregnancy, before again breeding her. The environment was such that accidents and errors occurred and a few cows were bred without the rest interval planned. In 1931, five of these, constituting the majority of the group, were recorded as having aborted; no abortions were recorded amongst the cows to which the rule had been applied. The incident sounds fantastic but to me it possesses

two attractive virtues: it is in full accord with the principle that the genital organs should have recovered their equilibrium from one pregnancy before commencing another, and it is in perfect harmony with such other observations as I have been able to make in this field. In the end, also, there were more and better calves and more milk.

There is no logical reason for expecting that conception occurring in a diseased uterus will end in the physiological production of young. Although the injuries may have been severe there is still reasonable hope that the animal may breed acceptably if ample time is allowed for the completion of repairs before again becoming pregnant. Some cows breed fairly well after the endometrium has been completely destroyed in one horn, if the other horn is reasonably healthy, but the smaller area must carry a correspondingly heavy load and pregnancy can not be so secure.

The added burden of heavy lactation in the dairy cow depresses her vigor and delays the involution of the uterus. Dairymen largely ignore this; frequently breeding the cow after an interval of 30 to 40 days and imposing an additional load when she is already faltering.

Twin conception throws an interesting light upon the problem. Twin conception in mares and cows generally follows a long period of sterility or occurs very shortly after the termination of a previous pregnancy before the reproductive system has regained its physiological equilibrium. Thus, in a highly sterile Thoroughbred stud, after effective measures had been applied to advance the rate of conception, twenty-six pregnancies comprised six pairs of twins. If twin gestation is commonly preceded and followed by sterility as indicated in Table I, page 273, or is closely associated with low fertility as shown in Table III, page 275, it logically follows that twin conception should occur frequently when the animal is bred too early after the close of the previous gestation. The reproductive system is in a disturbed state which may lead to the discharge of two ova in a uniparous animal. That being true it naturally follows that twin pregnancy is unsafe, abortion common, premature birth general in those not aborted and the outcome usually highly unsatisfactory.

Writers frequently mention "twin abortion" as a phenomenon apart from "contagious abortion." Their meaning is not clear. Evidently the two fetuses constitute an extra load upon the uniparous female, but that provides no explanation of why a uniparous female should break her law of reproduction by discharging simultaneously two fertilizable ova. The cause needs be sought in some genital disturbance which has affected the equilibrium of the ovaries. Sometimes this loss of equilibrium becomes very striking. Thus McIntosh[11] cites the example of a cow which aborted 10 fetuses within 20 months. There were two sets of triplets and two pairs of twins. The abortions are stated to have occurred at three to four months. Apparently there were intervals of not over 90 days between one abortion and the next multiple conception; an inadequate period of time for complete recovery from the previous disaster. The instance is reminiscent of a diseased fruit tree which blooms extravagantly when incapable of producing any fruit.

Twins are mostly males. The causes of an excessive ratio of males in twins apparently also operate in singles, with the result that sex parity is disturbed by genital disease with an apparent tendency toward an excess of males. In a healthy Hereford herd the ratio of bulls to heifers, amongst 94,436 calves at branding time, was 102.3:100. On the same ranch, separated by a wire fence, 873 grade Holstein calves showed a ratio of 119:100. In the purebred Holstein herd, also separated by a wire fence, the healthy heifers of Group A in Table III showed in their first pregnancy a ratio of 70:100, compared with a ratio of first calves in

Group B of the same table of 209:100. For the entire herd there is record of 62 aborts and non-viable calves with a sex ratio of 210:100. The matter is more fully discussed elsewhere[21]. The data at hand indicate that amongst sexually healthy dairy cattle which are not bred too rapidly the dairyman may confidently rely upon sex parity of his calves.

The Computation of Breeding Efficiency

The method of computing breeding efficiency has always been incomplete and vague. The ideal commonly expressed is that each mare and cow should annually give birth to one healthy offspring. Categorical statements occur of dairy herds which attain this ideal. It would be more intelligible if the facts were submitted instead; the fallacy of the categorical statements would then become apparent. There is the statement, for example, that in a purebred dairy herd consisting of 250 cows, each produced one calf annually for ten years. I have elsewhere[21] published a chart showing that a cow breeding so ideally and her female progeny being equally fertile, would have at the end of ten years, twenty-seven female progeny, or for the 250 cows there would be an increase of 6.750 females. No record is submitted to indicate what became of any of them. It is easy to so manipulate statistics as to show that a common herd has averaged one calf per cow for a given year. Sometimes the "calf" is a dead fetus. It is not scientifically nor economically a calf but is merely a statistical calf. Some writers list a first pregnancy heifer as having "calved normally" and promptly died from retained afterbirth. Statistically she made a perfect score but economically she was a total loss.

The complete record of a cow should include her entire life from the day of her birth to that of her death inclusive. With the complete record of milk production and the total viable calves borne a true valuation may be computed. Thus the great Holstein, Glista Ernestine, lived 5,871 days and produced 13 living calves or one calf for each 451.6 days. She yielded for each day of her life 34.4 lbs. milk and 1.6 lbs. butter.

There are many researches upon the cost of maintaining calves but no complete data concerning the actual value of the calf after it was raised. The authors do not state how many fail to breed or the ratio which abort their first pregnancy. The question of how to raise a dairy calf to insure its maximum efficiency as an adult has not yet received much attention.

The dairyman can not simultaneously have his cow produce the maximum number of calves and the maximum volume of milk. If bred too early after the close of the previous pregnancy the milk yield becomes depressed. The breeder of registered dairy cattle recognizes this principle when desiring to make long time records of milk and butter fat. He dries the cow off early and with heavy feeding endeavors to have her accumulate a maximum store of energy which may be drawn upon after calving. In addition he withholds the cow from breeding for an extra long period so that her energies may go wholly to milk production instead of sharing with the nutrition of the fetus. He sacrifices rapidity of calf production in favor of more profuse lactation. In Group A, Table III, page 275, the eight animals which first calved at less than 2.25 years produced during life, or if still living, up to May 31, 1930, a daily average of 17.3 lbs. compared with 15.55 lbs. for the nine animals calving first after 2.25 years. Various factors came into play and the influence of each is difficult to compute accurately. Many would attribute the difference to the influence of early breeding. An imperfect study of the records makes that doubtful. The group first calving after 2.25 years has produced more calves and at shorter intervals, which inevitably reduces the rate of lactation. The computa-

tion must remain incomplete while some of the animals continue breeding and milking. The heaviest milk yield generally was in the first and second years, before the strength of the animals of the entire group had been depressed by rapid breeding. A higher ratio of the group first calving after 2.25 years remain in the herd and may modify greatly the average milk yield per day. Naturally the average total milk per cow is greater in the group first calving after 2.25 years.

Following conception there was regularly a drop of at least 15% in the milk yield except at the close of a period of drouth when a sudden plenty of succulent forage reversed the order. The shorter the interval between calving and the resumption of pregnancy apparently the greater the decline. Thus heifer V was bred 62 days after her first calving, at the close of a protracted drouth and after a rainfall of 3.10 inches advanced 70 pounds the next month. Following the second calf she was rebred at 61 days and promptly dropped from 2,230 pounds to 1,957 pounds the next month in spite of a precipitation in the two preceding months of 12.39 inches. The strain of rapid breeding and lactation were becoming apparent. Her third pregnancy dropped to 276 days which should have served as a caution signal, but she was again bred at 39 days (30 days after she should have calved), twin conception followed with a pregnancy of 275 days. She then definitely staggered under the burden (probably had retained afterbirth), and was not rebred for 109 days. She failed, failed again 20 days later and conceived after a further delay of 20 days, and calved at 278 days, 7 days short of the ideal. Rebred 77 days later she calved at 282 days and was thereafter sterile. When breeding records are carefully studied, cow after cow will be found which vividly illustrates the principle that sexual overloading always menaces the breeding life of the individual.

If healthy, vigorous calves are to be produced—without which profitable dairying is impossible—the dual load of pregnancy and lactation must be kept well within the strength of the cow. A ton truck will probably carry a two ton load—for a while—but will soon be damaged beyond repair. A careful study of the herd illustrated in Table III seems to indicate that the dairy, as well as the beef heifer should not be bred to calve long before three years of age, and that the rest period between calving and again becoming pregnant should on no account fall below 80 days for a vigorous cow in the prime of life. Placing the normal duration of pregnancy at 285 days this allows an interval of 365 days between calves. The age and health of the animal should be considered carefully. The prevalence of abortion, retained afterbirth and other pathological phenomena of reproduction in dairy heifers bred to calve before three years indicates that the load has been too heavy for their strength; that it would be prudent, for the sexual health and longevity, that a long period of rest, perhaps five to six months, be granted after the termination of the first, before beginning the second pregnancy. After the second calving the rest interval may be reduced. As old age comes on the rapidity of breeding should be checked again and an effort made to so adjust the burden that it may not only be safely borne, under anticipated conditions; but that there shall be held in reserve a liberal degree of strength as a protection against unforeseen stresses. The rest interval between two pregnancies should be modified constantly, according to the health of the animal. If a heifer or cow calves at 245 days and is rebred 40 days later she will have become pregnant again on the day when she should have calved. When a cow calves at 275 days or less it constitutes a danger signal which the prudent breeder should heed, and apply as the greatest assurance against disaster a very liberal rest interval before the next conception.

Lecture No. 4.

The Role of the Male in the Pathology of Reproduction

THROUGHOUT history the female has been regarded as the basis of the pathology of reproduction. A few outstanding venereal diseases of domestic animals, like dourine of horses, the coital exanthema or vesicular venereal disease of horses and cattle and the venereal tumors of dogs, have been accepted as bisexual. In recent years these have become overshadowed by the frequent occurrence of abortion not generally attributed to the foregoing. With the advent of bacteriology it came to be believed that the vast majority of abortions were due to a specific bacterium, perhaps a special bacterium for each species of animal. Protazoa and filterable viruses were not being considered. The phenomenon of abortion is preëminently most abundant and destructive in dairy cows and naturally it was in them that the first efforts were made to discover the bacterium of contagious abortion. Professor Bang in 1896 found a bacillus, which he regarded as the cause of contagious abortion in cattle. His views were promptly accepted by investigators. It soon became evident that by no means all abortions in cattle could be attributed to the Bacillus of Bang. At first, those abortions in which the *Bacillus abortus* could not be found were conveniently attributed to accident, but further studies revealed that abortions were not uncommon when bacteria other than Bang's bacillus were present in the uterus. The observations of Willians, Udall, Frost and others[17] showed beyond doubt that all abortions are the immediate consequence of uterofetal lesions. The lesions described could not be explained except as the result of the invasion of the tissues by bacteria or other pathogenic organisms. Hence the belief in accident as a direct cause of abortion has been generally discarded.

Studies in genital pathology soon showed that abortion is merely one of a long list of consequences of genital disease, the culminating phenomenon being sterility, or close of the breeding life. Accordingly any force which might cause abortion could also lead to sterility, retained afterbirth and an endless chain of phenomena. Contagious abortion thereupon became an inclusive term which might mean any pathology of the genital system interfering with or destroying reproduction. At first it was believed that Bang's bacillus caused all abortions in cattle which were associated with bacteria. This was necessarily modified in varying degree according to the point of view of the individual. It is now admitted that many abortions and associated phenomena occur, in the absence of that organism. The symptoms, course and termination are so alike in all that it must now be held that any law or principle applying to one is identical for the other.

The old conception of contagious abortion as a female complaint still persists and serves as a formidable obstacle in the path of progress. There are powerful reasons for perpetuating the tradition. At the beginning Bang proposed that abortion be controlled by immunization or by quarantine and up to the present time investigators are divided into these two camps. The admission that the male plays a vital role in the pathology would embarrass or wreck either plan, according to the generally accepted details in the theories of the opposed camps. A thoroughly entrenched tradition becomes as sacred as a pagan god. It is undeniable

that a vast majority of aborted fetuses in all species of mammals are males. Nevertheless contagious abortion is regarded as a female disease. So the paradox appears of a disease of females which kills chiefly males.

Certificates of Health for Diseased Bulls

In this problem the voice of the clinician is rarely heard. Leading investigators as a body have firmly committed themselves to the hypothesis that if the male plays any part at all, it is a very trivial one.

With the expressed purpose of silencing antagonistic views, the American Veterinary Medical Association created an abortion committee in 1918. It was to be composed of the foremost authorities on contagious abortion, who would speak through reports; which, when adopted, would constitute the official and authentic position of the membership of the association. In 1921, I[15] took the definite stand that the sire constitutes one-half the herd unit, physiologically and pathologically as well as in pedigree, and declared that the fundamental basis for physiological reproduction consists of the mating of two sexually healthy individuals. In the following year the abortion committee in the performance of its bounden duty caused the association to go on official record that a bull, ejaculating abortion bacilli with his semen is a safe sire, if the copulation occurs on neutral ground and the cow is immediately so confined that she can not lick her vulva until all abortion bacilli which may have been ejaculated in the semen shall have escaped. The duration of such interval is not stated. Neither did the committee cite a case in which it had been shown that a bull had ejaculated Bang's bacillus with his semen. In the genital organs of bulls, abortion bacilli have been usually, if not solely recognized only in abscesses, and from these it is improbable, if not impossible for the bacteria to get into the semen. The danger from the stand taken by the American Veterinary Medical Association, and its current acceptance, does not lie in the direct statement but in the inevitable implications. The current attitude is that the chief, and sole important cause of genital disease in cattle is Bang's bacillus. Eradicate it, and physiological reproduction is *a priori* essentially or completely assured; the breeder may then proceed to ignore with contempt every basic law of sex hygiene.

The dogma officially established by the American Veterinary Medical Association that a genitally diseased male is a physiological sire places a formidable obstacle in the path of progress in breeding. The clinician knows only too well that any observations he may record which indicate that the use of an unsound sire will result in pathological conceptions in both number and quality will be largely or wholly obscured by the pronouncement of the highly influential abortion committee and its unanimous endorsement by the association.

The Owner's Stake in a Diseased Sire

Another great barrier to progress regarding the knowledge of the part played by the sexual diseases of the male in the pathology of reproduction as a whole is the attitude of some owners of famous sires, especially of race horses. The principle involved is alike in connection with a famous sire of any species of animal, when the owner is offering the services of the sire, at a high price, to the public. The handicap in controlling sex pathology by the scientific handling of the diseased sire is often insurmountable.

Fertility of Varying Degrees

Breeding animals of both sexes are divisible into three fairly well defined groups upon the basis of reproductive health; the totally and permanently sterile animals; those of low and uncertain fertility; and sexually healthy individuals.

There are numerous males which are totally sterile. They are of several classes. It is beside the point to discuss here double cryptorchidy and various aberrations or monstrosities of the genital system which inhibit reproduction,

beyond recalling that they are, so far as known, a natural sequence to conception from a diseased sire or in a diseased uterus. The owner needs no advice regarding their disposal. There are numerous young dairy bulls which are born in a state of apparently normal development which prove totally sterile at breeding age. How frequent this may be in young beef bulls or in young males of other species, is not a matter of record. Naturally, upon the general observation that dairy cattle are genitally the most frequently and seriously diseased of all domestic animals, there are certainly more completely sterile young dairy males than in other species and breeds. With others, I have described elsewhere[17] a bull calf, borne by a genitally unsound heifer after a long delay in conception, which was affected with abscessation of the testicles and adjacent urino-genital organs in a manner to indicate that the infection became implanted while he was yet in the diseased uterus. While he could not, apparently, have lived to breeding age, it is easily understood how less serious infection might persist and bar reproduction. This seems to occur. At least young dairy bulls sometimes ejaculate only fragments of spermatozoa, suggesting rapid bacterial destruction.

Progress Made in Clinical Studies

New impetus has been given recently to the question of the diseased male transmitting destructive genital infection to the female. In 1928, Prof. Dr. Reisinger[13] made careful clinical bacteriological and experimental studies of extensive outbreaks of abortion and associated pathological phenomena amongst dairy cattle in Lower Austria. The havoc commonly followed closely upon the introduction of a new community or parish (Gemeinde) bull. The malady was characterized by the appearance of a marked vulvo-vaginitis with swelling and profuse, muco-purulent genital discharge following coitus within a day or two. The symptoms abated, and usually subsided within 10 to 15 days. Later numerous cows, which had apparently conceived and did not again come in heat, developed a muco-purulent genital discharge. Clinical search revealed many cases of pyometra, in a large proportion of which there was later found a macerating fetus, usually quite small, indicating a development of 8 to 10 weeks. It was not abortion in the ordinary sense, but fetal death with pyometra and purulent maceration without expulsion. Further investigations revealed the presence of vesicular venereal disease or coital exanthema; Reisinger, with excellent reasons, attributed the destructive genital disease to that infection. The type of disease was especially pernicious because of the well known fact that pyometra of long standing commonly signifies the end of reproduction whereas in ordinary abortion a considerable proportion of cows so far recover, that they may breed fairly well.

The conclusions of Reisinger were revolutionary because the vesicular venereal disease had always been regarded as a highly transmissable, fleeting malady, which interrupted the march of reproduction during its brief course of a week or two; ending in complete recovery without having caused any permanent damage.

In 1929 Lothe[9] made a notable contribution based upon his observations in a large herd in which genital disease was extremely virulent. By the usual standards Bang's bacillus could be held responsible in only a minor degree. As in Reisinger's cases, one of the outstanding phenomena was pyometra, but no macerating fetuses were observed in the pus. Lothe submits convincing evidence that much of the pyometra was due to one of the bulls that was used. A careful study of spermatozoa of this bull revealed no defect. That was highly significant because as a rule such examination is very reliable; the dangerous bull reveals the fact in his spermatozoa.

Now, in 1932, comes a third paper which may pardonably be classed as epochal, contributed by Küst and Uhrig[8] of the

University of Leipzig. In their ambulatory clinic they investigated the prevalence of highly virulent and destructive genital disease with many abortions, much sterility, numerous cases of pyometra with macerating fetuses floating in the pus, etc. Their researches included eight communes or parishes in which the bulls were owned and managed by the community (Gemeinde), and two manorial estates where the bulls were privately owned. The vesicular venereal disease (Bläschenausschlag) was definitely recognized in one or more animals in each parish and estate. Küst and Uhrig kept in the fore the search for Bang infection, and obtained one positive reaction to the agglutination test; but no positives to bacterial search. The abortions were in *early* gestation, some fetuses not over 2 inches (5cm.) long. Küst and Uhrig were very positive that the basic cause was the vesicular venereal disease and the agent in transmission was the infected sire.

While in the Continental European states this venereal disease has long been reportable as a specific infection subject to official control, it has not been regarded as having any significance, beyond the local lesions which quickly subside. So Hutyra and Marek[6] speak of it as virtually harmless except for temporary suspension of breeding and some interference with lactation. The disease is not rare in dairy cattle in America; I have not observed it in beef cattle and find no reference to it in literature.

The infection is important here as an example of a highly virulent and destructive force in the pathology of reproduction which is clearly bisexual and transmitted to the female by the bull in coitus. There is no logical reason for the assumption that it is not merely one evidence of a general principle that any infection pathogenic for cattle may be transmitted from male to female in coitus if the semen or the exterior of the penis is contaminated with the bacterium or virus. If the Bang infection is not transmissable by coitus it is because the bacillus is not introduced into the vagina. If a bull ever ejaculates Bang's bacillus with his semen and he should copulate with an animal like the five heifers I have mentioned, which were so highly resistant that they defied intravenous and natural exposure to that organism, it is not to be feared that they would become diseased through coitus.

There are numerous young dairy bulls which arrive at breeding age totally sterile; some exhibit no sexual desire or male conformation, others have the male somatic characteristics, normal sexual desire and copulate freely but ejaculate no spermatozoa. In the former, apparently the interstitial testicular tissue, the hormone of which is regarded as being responsible for sexual desire, is not developed and presumably the formation of spermatozoa also fails. The testicles are small, the head, neck and voice are those of a neuter. In the other, more common group of cases the testicles are small, ¼ to ½ the normal volume, and histologically the tissues which should form the spermatozoa are juvenile as in cryptorchid testicles. The actual cause of the defect is undetermined. Since it has been observed entirely in dairy bulls (though it probably occurs less frequently in other males) there is ample reason for the suspicion that it constitutes the male analog of the juvenile genital system of heifers described on page 276 and is to be attributed to bad health in early calfhood.

Sterility Increases with Age

Like dairy cows, a large proportion of dairy bulls eventually become totally sterile. The causes of such total sterility have not been adequately studied. Less frequently, though not at all rarely, males of other breeds and species become totally sterile. Sometimes there is abscessation of the testicles; sometimes induration and atrophy or other changes. Inflammation and abscessation of the seminal vesicles of bulls occasionally occur and bar the formation of their secretion; highly im-

portant as a fluid vehicle for the spermatozoa. In various ways the formation and discharge of spermatozoa are blocked and total sterility ensues.

The male with juvenile testicles is innocuous, and the loss is limited to the individual. He does not imperil the breeding health of other animals. Total sterility works its own control. As soon as total sterility is recognizable the breeder naturally discards the worthless sire.

Observations upon absolutely infertile males are probably responsible for much of the current misconception, that sexually unsound sires are not inimical to the health of the females bred to them or of the progeny. Numerous cases are recorded, by laboratory workers, of their studies of the genitalia of totally sterile males. The investigations are commonly limited to the study of the diseased organs and contribute little information as to the breeding history of the animal prior to the advent of total sterility. When an animal of either sex becomes totally infertile there is a tendency for their menace to other animals to cease. This is most marked in the male because in numerous instances he either ceases to ejaculate or to copulate. For example, genital tuberculosis of the cow may render her absolutely sterile but leaves her with undiminished sexual desire and capacity to copulate. She is extremely dangerous to the bull which may copulate with her and promptly acquire preputial, penial or peripenial tuberculosis, which destroys his power to copulate, although his basic genital organs—testicles, seminal vesicles, etc. — remain sound. The cow thus becomes, in the traditional sense, responsible for venereal tuberculosis, which she transmits to the male, while the latter, in many cases, can not in turn, transmit the disease venereally to the cow.

The Real Menace

The great outstanding menace of genital disease to livestock husbandry is associated with low fertility, not with absolute infertility. The absolutely sterile animal provides no complex problem in the control of the pathology of reproduction. The individual is a complete loss which can be computed immediately and accurately. The feebly fertile animal, the bull which may get one recognizable pregnancy by three to ten copulations with healthy cows; or the cow which shows recognizable pregnancy, only after three to six months or more of breeding effort, constitutes the major peril both immediate and remote. The losses caused by sexual disease of an animal is not always readily or accurately computable. The immediate results may be estimated as soon as the diseased individual has recovered its health or has been discarded. The most serious losses are usually remote and continue to act through generations; the disease becomes an integral part of the pedigree. The principle is more readily traced in the female line.

A Holstein cow of fair pedigree gave birth, as a heifer to a bull calf, her second calf was a bull, her third gestation resulted in the abortion of twins, her fourth gestation produced a viable heifer and the cow then made a world's record for butter fat. She became a nymphomaniac. I attended her for a year or two in vain. Others attempted her cure and after four years she again conceived, gave birth to a non-viable bull, after which she was discarded. I handled her one heifer for sterility during the first breeding year and she produced a viable heifer. She was again handled for sterility, conceived and produced a viable bull. She was handled a third time for sterility, failed and was slaughtered. Her one heifer in turn conceived; was in dystocia at term, the fetus was extracted dead and the heifer died. The three viable bull calves produced by the three generations of females were sold at high prices because of their pedigree but so far as recorded, the high cost was the only notable feature in their history. While in some instances the sexual health turns upward and an

efficient breeding line of females originates from a diseased source, the reverse is more common. A genitally unsound animal of either sex is a frail and dangerous foundation for breeding, except adequate measures are taken to break the vicious circle. My observations so thoroughly convinced me of this that in 1921[15] I took the definite position that the first principle in physiological reproduction consists of the mating of two sexually healthy animals. This was followed the next year by the counter statement of the American Veterinary Medical Association cited in the foregoing that it is not essential that the male be sexually sound. Additional data were assembled and I again defended my point in greater detail in 1923.[16]

Factors Lowering the Fertility of Bulls

As in the female, so in the male, two correlated factors occur—the depression of the individual and the presence of bacteria, viruses or other form of contagion. The basic unit in procreation on the part of the male is the individual spermatozoon which fertilizes the ovum. If that spermatozoon be wanting in vigor, the resulting fertilized ovum must be correspondingly weak. Any element which depresses the vigor of the male, whether dietetic errors, excessive physical exertion (overwork), close confinement or overbreeding, inevitably affects, unfavorably, the number and vigor of the spermatozoa. It has been stated in the foregoing that numerous dairy bulls arrive at breeding age with a degree of arrested development of the testicles which renders them absolutely sterile. It is logical to assume that a greater number suffer from a lower grade of arrest in genital development, not so readily recognizable clinically. These would be expected to be weak, their spermatozoa imperfect and their genital tract without efficient defensive powers against bacteria and viruses. This would be expected to lead to gross deficiency in number, form, structure, vigor and resistance of spermatozoa. This occurs. A fashionably bred young bull, ready for service, was offered to a prospective buyer in a foreign country. A test service was made and his semen examined. It was very scant, the spermatozoa were so few that it required much search to discover any. Those found consisted largely of detached heads, and these were abnormal in size and form. No spermatozoa could be discovered which could be suspected of being physiological. Another test service was made with identical result. The breeder was definitely advised to withdraw the bull from sale, but the animal appeared so vigorous and promising in general appearance, that the breeder could not accept the advice and completed the sale. Later he refunded the price of the bull and the heavy transportation charges. Lesser defects are common in young dairy bulls and doubtless occur more rarely in beef cattle and in young males of other species. Such imperfectly developed bulls in all probability sometimes carry infection in the weak reproductive organs from early calfhood to breeding age.

Unquestionably the want of vigor in the genital organs invites infection as soon as the bull is used as a sire. Not infrequently there are definite clinical evidences of genital disease. Thus in Table V., the diseased bull was purchased in a herd where the calves were all very unhealthy. Havoc appeared among his cows, as soon as he began service, and continued to the date of his slaughter. Upon examination it was found that the left seminal vesicle had abscessed and emptied into the rectum. Pending the abscessation there would logically occur a discharge of contagion with the semen, and the conclusion is essentially inevitable that the right seminal vesicle also harbored contagion and discharged it as an integral pollution of the semen. That is, diseases of paired organs have a marked tendency to be bilateral: when one ovary is cystic, the other commonly suffers similarly, salpingitis is usually bi-

lateral, etc. As shown in the table, the bull could not be said to have been overworked, and the disaster must be attributed to factors already established when he came of breeding age.

In other bulls there are definite evidences of sexual overload, with parallel results to those observed in females. This is well illustrated in Table VI. outlining the breeding results in a registered Hereford herd. The data in Table VI.

In his third breeding year Bull 1 made 82 copulations. The chief effect upon his fertility should appear in the following year when there occurred a decrease in his conception rate. He then copulated 117 times in 1914 with a very definite drop in fertility in 1915. At this juncture his load was decreased and in 1916 his fertility notably rose. So in general, additional sexual load is commonly reflected in the next year in the form of receding

TABLE V

No.	Number Live Calves Born	Average Duration Pregnancy in Days	Services per Calf	Duration of gestation in days										Per Cent of Abortions
				270 days or Less		271 to 275 Days		276 to 280 Days		281 to 285 Days		286 to 290 Days		
				No.	%	No.	%	No.	%	No.	%	No.	%	
7	30	276.	4.1	6	20.	7	23.3	9	30.0	7	23.3	1	3.3	34.8
3	19	284.5	2.9	0	0	0	0	3	15.8	7	36.8	9	47.4	13.6

TABLE VI
Breeding Summary of Two Hereford Bulls

No.	Year	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	Total
1	Copulations	8	39	82	117	73	106	106	86	64	10	691
	% Calves	100	33	34	32	27	39	27	26	28	90	32
2	Copulations	23	70	61	37	35	6	0	3	2	1	213
	% Calves	83	54	33	41	40	0	0	33	0	0	50

are typical of the breeding histories of many males. Bull 1 was more highly regarded than Bull 2, and more heavily bred from 1913 onwards. At the outset as a two-year-old he was less heavily used than Bull 2.

These two bulls were handled alike, in the same herd. They were out of doors throughout the year, subsisted on natural forage, supplemented with a light ration of grain.

Bull 1 produced 136 bull calves and 85 heifers; Bull 2 produced 62 bulls and 44 heifers. In 1920 the heifers of Bull 1 had a total progeny of 163, while Bull 2 had 162.

fertility. The fertility recovered in 1919-1920 when the load had been decreased.

Bull 2 was the weaker sire. He was bred three times as heavily in 1911 and almost twice as heavily in 1912 as Bull 1. The rule of advance and retreat in fertility remained as in Bull 1 until he collapsed late in 1915.

It is the common belief of dairymen that young bulls, two to three years old, are the most fertile. That is untrue of the diseased bull in Table V., but becomes apparent in Table VI. More important in Table VI. is the clear implication that both animals were most successful at the outset because they had stored up energy

which was drawn upon in meeting the sexual demands during the first two years. The store of energy then became exhausted and the sexual power had to be sustained from day to day by the food supply. Five years of breeding served to wreck Bull 2 beyond repair. The load imposed upon him while immature, suggests the reason for his early breakdown. In the meantime he had produced far more calves in 1911-1912 than had Bull 1. Bull 2 having been the more heavily bred at first, he naturally had more heifers of breeding age in 1913-1914.

The capacity of a sire for service is modified by age, nutritive supply, exercise and an endless number of factors affecting health and vigor. The burden which one sire may bear is no criterion of the ability of any other. In Table III., page 275, it is perfectly clear that Group A was competent to carry a greater load than was either Group B or Group C. The principle is alike for the male. A young dairy bull arriving at breeding age with defective genital development may render an acceptable service if the burden is adapted to his strength.

Many writers on animal husbandry recommend that a mature dairy bull be assigned 100 cows. Since the average rate of copulation per recognized pregnancy rarely falls below two, this means 200 copulations per annum. The beef bulls in Table VI. staggered under one-half that load and one broke down completely. It is perfectly well established that some bulls have been able to carry such a load, but according to my observations. and available data, the placing of such a burden upon dairy bulls is an utterly unwarrantable risk.

Haubold[5] records an instance where a bull with an assignment of 100 cows got 23 twin conceptions and five monsters. Since both twins and monsters must be attributed to pathological conditions, the observations of Haubold fall within logical limits. While not definitely stated by Haubold, the twin gestations probably followed the death and unseen disappearance of small fetuses with destruction of the reproductive equilibrium, as is the rule with twins. The computation must be based upon knowledge of the individual, associated with general observations upon a large number of sires. As in females, so in males, age needs be carefully considered. Many bulls are hopelessly injured during the first and second years of breeding—at two and three years of age. Breeders are influenced in favor of early use because the young bulls, under the usual methods of handling, are conspicuously fertile, their keep is costly according to current methods, and the prices paid for the bulls are frequently very high, so that the interest on the investment urges haste in dividend earning. Reliable data upon the influence of early breeding of dairy bulls on their longevity and breeding efficiency are wanting. The principles which apply to the age at which heifers should be bred must be equally correct for bulls. It needs be granted, that a copulation by the male is not at all comparable to the burden of a pregnancy by the female. The generalization might be made that if it is advisable that a heifer be bred at 21 months to calve at 30 months, then a bull of the same age might safely serve a number of cows which would place upon him the same burden as the pregnancy of the heifer, but that is an undetermined equation. Logically it would appear highly imprudent to put a yearling bull to work and dangerous to use a two-year-old extensively.

Many owners of grade cows place a yearling or two-year-old bull at pasture with the herd. This practice is highly dangerous to the sexual health of the herd. The young bull will copulate repeatedly in rapid succession with one cow. If she chances to be in low genital health, she may continue in heat for two or more days, and, even if no other cows came in heat in the meantime, the sterile cow would be back in heat before the young bull had had adequate rest and the excessive burden is resumed. If conception

occurs, the fetus is weak and likely to die in a few weeks, subjecting the cow to all the hazards of that catastrophe.

The Determination of the Sexual Fitness of the Male

There are three methods by which the sexual health and breeding strength of a male may be measured.

I. The supreme test of a sire is his breeding record. The prudent breeder should on no account fail to keep an accurate record of the services of each sire. The record should preferably be in tabular form, having a complete list of the females assigned with ruled columns for each month in the calendar year so that a glance at the table will show the degree of concentration of services at a given time and their success or failure. While the breeding record is essential in the final determination, it is wholly inadequate as an initial measure. The careful breeder will first apply other tests. The diseased bull in Table V., page 294, had wrecked the herd before his dangerous character was recognized. Such disasters can be guarded against only by applying the second and third plans for determining sexual health.

2. The physical examination of the male is of distinct value, though it has important limitations. The clinical examination reveals the presence of active disease of the genital organs as well as inherited or acquired defects, like cryptorchidy, abnormal size, form or consistency of testicles, penis and seminal vesicles. Such examination often reveals highly important diseased states, which may lower the fertility and value of the sire, or threaten the health of the herd.

3. Next to the breeding record itself, the most accurate and valuable test of the fertility of the male is the microscopic study of the semen. The spermatozoon is the vital basis upon which the value of the sire depends. Without perfect male cells, physiological reproduction is impossible. Like all standards of diagnosis, it has its limitations. Three different standards are used.

a. The most primitive and least reliable test is the abundance and motility of the spermatozoa in the freshly ejaculated semen. If spermatozoa are few or absent, or if the spermatozoa are non-motile or feebly motile, the animal is infertile. Spermatozoa may be abundant and motile, but imperfect in form, size and structure; the male therefore of low fertility and, probably, dangerous.

b. A second and more important standard is the duration of the motility of the spermatozoa. Reisinger[13] has found that the spermatozoa of a healthy bull retain their motility at room temperature for 12 to 24 hours, while those from bulls having the vesicular venereal disease become non-motile within two hours perhaps due to the presence of the virus of that disease. In how far this is generally applicable is uncertain. Because of the sensitiveness of spermatozoa to temperature, the test should be comparative, semen of known health being used as an immediate check.

c. The third and most valuable standard is the study of the fixed, stained spermatozoa under high power oil immersion. Properly prepared, defects of the spermatozoa in size, form and structure are authentically revealed. The male cells are enumerated readily and the ratio of abnormal to normal sperms determined accurately. The ratio of abnormal spermatozoa per thousand is the most valuable basis known for the accurate determination of the degree of fertility except for the highly expensive test of breeding. The examination of the stained spermatozoa eliminates in the highest available degree dangers to the male when unfit for service when rest might yet restore his value. It also reduces to the minimum the peril to the female when the defective spermatozoa menace the safety of pregnancy. The test is widely available. The semen may be procured by any intelligent layman, after simple instructions, and may be transported any distance and the examination made leisurely after several days, weeks or months. It is comparatively in-

expensive and hence economically applicable to sires of ordinary value. It may be applied to groups of males, as in large herds of range cattle.

Like all tests, it has its limitations. So in Lothe's[9] instance, the stained spermatozoa revealed no fault, but clinically the bull was dangerous. Lothe was dealing with an undetermined factor, a sort of "virus x" which may possibly have been the vesicular venereal disease. The inference is possible, from the contribution of Reisinger[13] that the spermatozoa while in the vas deferens were healthy, and that the virus was in the seminal vesicles or prostate gland, so that at the moment of coitus, when the fluids were united with the spermatozoa to constitute the seminal fluid, the virus became an integral part of it, and came in contact with the spermatozoa. This inference is strengthened by the further observation of Reisinger, as well as that of Küst and Uhrig[18] that the infected sire was fertile, but the embryo or fetus succumbed early, to the virus ejaculated with the semen at the time of copulation. After ample allowance for such limitations, the study of the stained spermatozoa remains a test of unusual merit, and applied at reasonable intervals, constitutes the most reliable means known for recognizing and controlling the perils of genital disease in the male. The technic for the test is comparatively simple can be mastered by any one with a moderate knowledge of microscopic methods.

Few examples of healthy and diseased tissues or cells, exhibit greater contrasts than those which become apparent between typically healthy spermatozoa and those which are equally typically diseased. The gap between them is naturally occupied by every gradation. The principle may be well illustrated by photographs of spermatozoa from healthy and diseased stallions and bulls.

For the stallion typical spermatozoa are shown from four famous sires. Fig. 1 shows a representative group of spermatozoa from a stallion which as a three year old was regarded as the greatest racehorse in America. The spermatozoa were obtained when he was seven years old and highly fertile. At that date his sire, then 20 years old, was highly fertile and his spermatozoa were equally perfect. A study of the cells show them to be quite uniform in size and form and of even contour.

Fig. 2 is a representative group of spermatozoa from an aged stallion of barely fair fertility. The photograph shows marked variations in size and contour of a considerable proportion of the cell heads, bodies and tails. With such spermatozoa, high fertility is not possible, and as the fertility declines the danger arises of a pregnancy which may end in death of the embryo or fetus with menace to the uterus from decomposition of the fetus and its membranes.

Fig. 3 shows typical spermatozoa from a stallion famous for his performance on the turf and for having produced notable racehorses. His spermatozoa were scarce and the photograph shows that it is difficult to find two cells which are alike. In midfield is a spermatozoon with a small, blunt, almost round head and a middle piece consisting of a slender thread. This lesion is present in one or more cells in almost every field examined. It is a common lesion in the spermatozoa of stallions of extremely low fertility, associated with marked danger for the sexual health of the mare. At the date when the semen was obtained it was fairly well known in some circles that the stallion had produced few foals during several seasons previous, but some owners were continuing to breed their mares to him at $1,000.00 for the season without insurance. Most mares bred to him proved incapable of conception later when mated with healthy sires.

Figure 4 represents spermatozoa from a famous stallion which had become hopelessly diseased, and was one of several noted sires to which my client had booked mares. In an effort to safeguard the interests of my client, semen was obtained

from each stallion for examination. The terms for this stallion were $1,000.00 for the season without insurance of either foal or pregnancy. His spermatozoa were so very bad that I forwarded samples of his semen to two preeminently able colleagues in this field without revealing to either of them my own views. The results of the examinations were alike by all three of us. There were at least 700 abnormal spermatozoa per thousand. The sperms were so irregular in size and proportions that it was virtually impossible to fix upon any one as a reliable standard for comparison. All three of us expressed the positive opinion that the horse was sterile and highly dangerous to mares with which he might copulate. The figure represents faithfully the general character of his spermatozoa. Almost no two cells appeared alike in any microscopic field amongst the many examined.

The owner of the stallion required that mares booked for breeding should have a certificate of genital health based upon a bacteriological search conducted by his veterinarian. This was ostensibly designed to protect this abominably diseased stallion against any possible infection carried by the mare. In order to render this stand plausible he also had his veterinarian make a seminal examination of the stallion, and issue a certificate which might be shown to the owners of mares to convince them of the sexual soundness of the stallion. The certificate stated that there were many motile spermatozoa and that *some* of them were imperfect. The effect of such certificate upon the owner of a mare would depend largely upon the shade of meaning allotted to *some,* whether he meant thereby 8, or 800 abnormals per thousand.

The feelings of the owner of the stallion toward me call for no comment. Neither was the situation rendered more happy by the fact that the evil effects of breeding to such a stallion soon became disagreeably evident to owners of mares and the dishonorable source of income from a dangerously diseased sire ran dry.

The veterinarian dependent upon such owners of badly diseased sires needs step lightly, speak softly, and handle in silence the disease transmitted to the mares.

Just how such sires render their females infertile when later bred to a healthy male has not been fully determined. It is highly probable that the greatest injury occurs in those females in which conception takes place and the embryo or very small fetus dies and decomposes within the uterine cavity and thereby causes greater irritation than had fertilization of the egg failed. That would parallel the observations of Reisinger[13] and Küst[8] with bulls affected with the vesicular venereal disease, in which the cows conceived, the small fetuses died, macerated and brought to a close the breeding life of the cows involved.

When an ovum of a mare becomes fertilized by a spermatozoon of an ass the only possible progeny is a mule. In rare instances the mule may breed. Even so, it remains a mule. Such hybridization vividly portrays the inescapable part played by the spermatozoon upon the character of any resulting progeny. The breeder of horses who would knowingly mate his mares with stallions producing such spermatozoa as those depicted in Figures 3 and 4 would not lower his prospects by mating his mares with a jackass. He might at least produce some valuable mules.

The micropathology of the semen of bulls is equally important and significant to that of stallions. The problem has been chiefly worked out by W. W. Williams and A. Savage. Naturally the chief researches have been made upon the spermatozoa of dairy bulls. In very rare instances a bull may show low fertility and high ratio of abortion associated with highly motile spermatozoa which reveal no evidences of disease when studied under the microscope by the best technic yet developed. The sexual health of the bull must then be determined by the highly expensive method of trying him

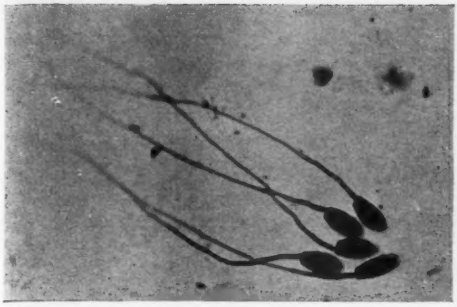


Fig. 1. Spermatozoa from a highly fertile stallion. x 1200. Photographed by A. Savage
Note the uniformity of size, shape and evenness of contour. No modern veterinarian, when examining a male for soundness as a sire, will neglect a careful study of the spermatozoa. The absence of an abundance of actively motile spermatozoa in the fresh semen indicates clearly that the male is a poor breeder or sterile; but the presence of an abundance of highly motile cells does not assure fertility or safety. It is preposterous to search with great care for sidebones, spavin or other alleged transmissible defects and at the same time to ignore the far more basic question of healthy spermatozoa. Yet it is a notable fact that in examinations of stallions for governmental approval, ringbone is regularly a cause for withholding a license, while the character of his spermatozoa is not determined

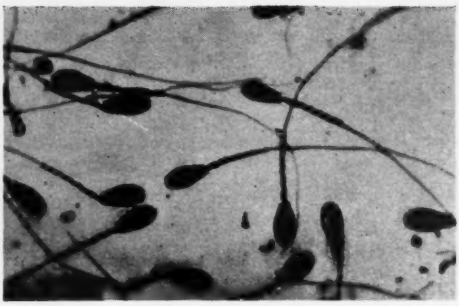


Fig. 2. Spermatozoa from an aged stallion of impaired fertility. x 1200. Photographed by A. Savage
Note the variations in the size and shape of the heads, bodies and tails. Many healthy mares bred to such a stallion will be returned frequently, thus overtaxing his waning fertility. If the usual number of mares are booked for the season, there will be a low percentage of foals, abortions will be frequent, dystocia will be common, the duration of gestation will often be excessive and the foals born will be of low vitality. There will be a definite tendency towards sterility among the mares following the mating with such a sire, and the sire himself will become increasingly infertile due to sexual overloading

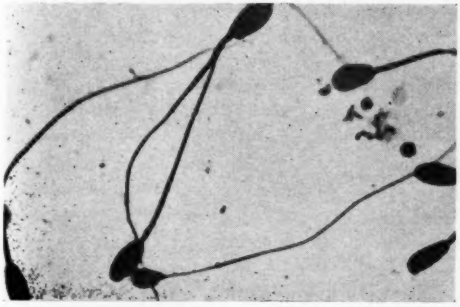


Fig. 3. Spermatozoa from an almost completely sterile stallion. x 1200.—Savage
Observe that no two sperms are alike, but vary markedly in size, form and contour. They were sparse in number. Many of the heads had become separated from their tails —a reliable indication that they are of low vitality. Only a man of low intelligence would knowingly mate a valuable mare with such a stallion. The chances are 9 to 1 that no foal of any value, would be obtained. Even more serious than the loss of his stud fee, is the definite prospect that the mare will be grossly damaged or hopelessly ruined as a breeder for all time

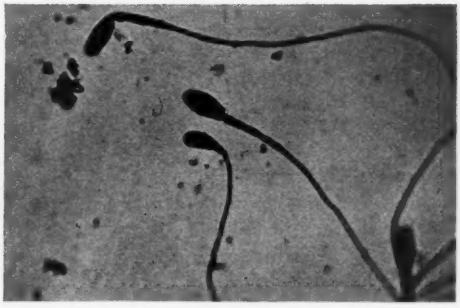


Fig. 4. Spermatozoa from an infertile stallion. x 1200. Photographed by Savage
The irregularity of the sperms is very marked. The larger of the discrete dark objects are misshapen heads without tails. The spermatozoa were few and only feebly motile. Breeders knowingly patronizing such a stallion face three certainties and one disagreeable prospect. They are (1) sure to lose the stud fee; (2) to get no valuable foal; (3) to lose the use of the mare for the season, and (4) the mare will probably be sterile thereafter. The placing of such a stallion in the stud, knowingly, and soliciting the patronage of the owners of mares is nothing short of deliberate fraud

out in the herd. In almost every case the safety of the bull as a sire is determinable authentically by an examination of the spermatozoa. The limitations in correct diagnosis, so far as known, lie wholly in the direction of erroneously concluding that the bull is sexually healthy when he is diseased and dangerous; no bull showing definite and extensive pathological changes in his spermatozoa has proved a fertile and safe sire.

In Fig. 5 is shown a group of spermatozoa from a highly fertile bull. The sperms are uniform in size and form and each cell stains alike in its various parts. The staining of bovine spermatozoa has been more successfully worked out than in the case of the equine cells and the parts come out far clearer. In Fig. 6 is show some spermatozoa from a bull of very low fertility. There is gross variation in size and form of heads, bodies and tails and in manner of taking the stain. In Fig. 7 the variations are yet more gross than in Fig. 6, the heads are larger, no two heads are alike and the bodies are equally variable in form. The heads reveal no differentiation in the taking of the stain by the various portions, in very sharp contrast with Fig. 5, in which each tissue comes out vividly. Fig. 8 illustrates the spermatozoa from an essentially totally sterile bull. The sperms have been arrested in development (microspermia) and have reached only a fraction of the normal size, most heads are without tails, no two are alike in size or shape or in the manner of taking the stain.

Form and color of the progeny are influenced no more definitely by the character of the fertilizing spermatozoon than are the health and vigor. It has apparently been assumed that of the many billions of spermatozoa in a single ejaculation, only a healthy cell may fertilize an ovum. This invites the further error of inferring that if a sufficient number of motile spermatozoa are present in the semen to make it probable that one may reach and fertilize the ovum, the male is *a priori* a healthy sire. Clinical observation emphatically denies this. The conclusion is illogical when based upon a study of either the fresh semen or the stained spermatozoa. Highly motile spermatozoa, examined under high power, often reveal marked defects in size, form and other respects. Thus in Fig. 7 are seen some cells with spindle-shaped swellings of the middle piece, of such form and size to compel the conclusion that the sperm was separated from the sperm-forming tissues before development had been completed. It then suggests an analogy to premature birth and clinical experience indicates that where such defects of sperms are common, the few conceptions are of scant value.

As the ratio of defective cells advances, the fertility and safety of the sire recedes. If it be assumed, that as a rule the ovum is fertilized by the most vigorous of the spermatozoa, it must then be concluded from clinical observation that the higher the ratio of visibly defective cells, the greater the probability that the apparently healthy spermatozoa are in fact abnormal, although the defects are not revealed by the present technic for examination. It naturally follows that the higher the ratio of visibly defective sperms, the greater the prevalence of sterility, abortion and other phenomena associated with the pathology of reproduction. When abortion occurs Bang's bacillus will perhaps be recognizable, there may be present a spirillum, a streptococcus, a protozoan or the intangible "virus x."

It not infrequently occurs that a young bull when arriving at breeding age, produces only semen like that in Fig. 8. So far as at present determinable, the basic cause lies in the unhealthy condition of the bull as a young calf, and is analogous in nature to the defective development of unhealthy dairy heifer calves. Healthy calves can not be produced by bulls with spermatozoa like those shown in Figures 6, 7 and 8, any more than good horses can be produced by mating a mare with

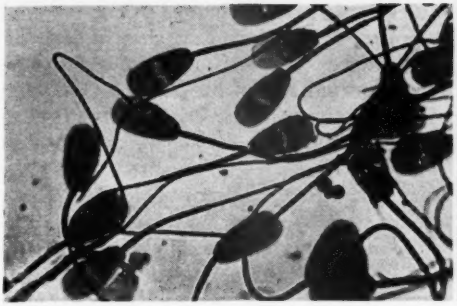


Fig. 5. Healthy spermatozoa from a highly fertile bull. x 900. (Courtesy W. W. Williams and A. Savage)
The sperms are uniform in size and form, even in contour and each portion takes the stain in a distinctive manner

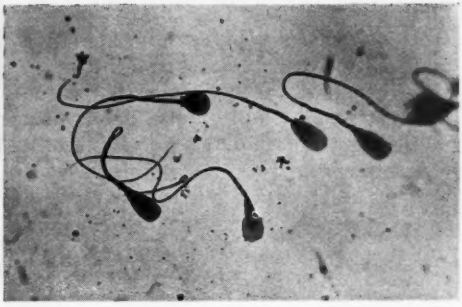


Fig. 6. Spermatozoa from a bull of very low fertility. x 650. (Source same as Fig. 5.) No two sperm heads are at all alike in size, shape or affinity for stains. Cows require many services for recognizable conception from such spermatozoa and many pregnancies end in abortion, retained afterbirth, etc.

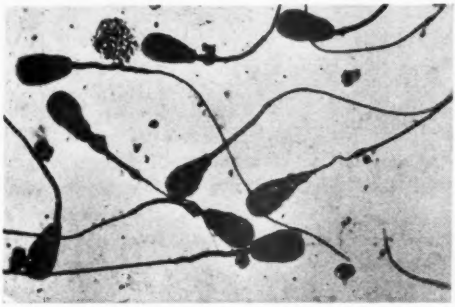


Fig. 7. Spermatozoa from an almost totally sterile bull. x 650. (Courtesy W. W. Williams and A. Savage)
The sperms are wholly unlike in size and form. All the cell parts take the stain alike so that there is no differentiation of cellular parts. Only rarely can a cow conceive when bred to such a bull. Even then, the conception is generally a calamity, the fetus dies early and its decomposition so injures the uterus that the breeding life of the cow is closed

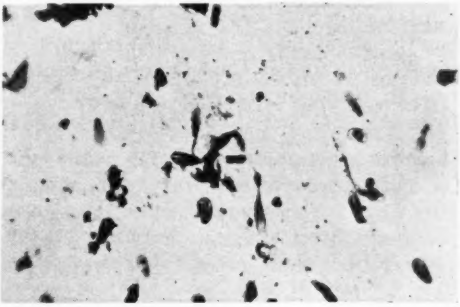


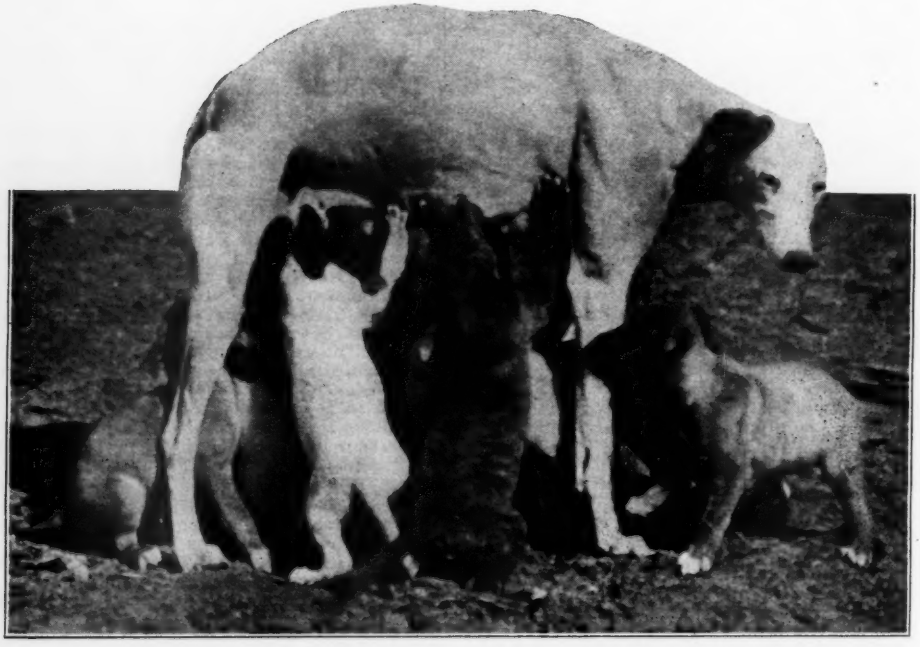
Fig. 8. Spermatozoa from a totally sterile bull. x 650. (Source same as Fig. 7.) Compared with Figures 5 to 7 the spermatozoa are extremely small (Microspermia). The heads are almost wholly without tails, they vary widely in size and contour and each cell takes the stain differently. Such semen is not rare in young bulls when first placed in service and so far as known they never recover. The cause apparently lies in faulty nutrition during early calfhood. The condition has not been recorded in beef cattle. The available evidence indicates that the condition is analogous to the defective sexual development of heifer calves as discussed in the second lecture and illustrated in Tables I to IV. The only remedy known at present lies in the maintenance of health and vigor in the young calves

a jackass. The barrier can not be overcome by inoculation with Bang's bacillus, by isolation of the female upon the agglutination test, by the administration of any alleged abortion or sterility remedy, nor even by the previously cited official proclamation of the American Veterinary Medical Association that a sexually diseased bull is a healthy sire. The cause lies deeper and needs be controlled at its source.

The sexual health of males, as deter-

Such extreme cases serve to emphasize the importance of healthy calfhood, because they lead inevitably to the conclusion that every gradation occurs between the hopelessly defective genital system illustrated in Fig. 8 and the typically healthy reproductive apparatus depicted in Fig. 5. Such gradations are constantly met in practice and the fertility of the sire and the vigor of the progeny rises and falls in harmony with the relative health of the spermatozoa

mined by the basic test of physiological spermatogenesis is practically ignored. A majority of the states in the union solemnly exclude the importation from another state of a bull whose blood reacts to the agglutination test for Bang's bacillus, but heartily welcome the introduction of bulls with such spermatozoa as those illustrated in figures 6 to 8, ostensibly to advance physiological reproduction. Many states, under similar technic and pretense, establish *abortion-free herds* and lead dairymen to infer that if a bull is negative to the agglutination test, he is therefore *sound,* even though his spermatozoa are appallingly pathological. An extreme case which vividly illustrates the inadequacy of the official examination of bulls, bordering upon the ludicrous, recently came under my observation. A quadruped born in Canada was registered in the Holstein herdbook as a bull. It was sold into one of the states which has cultivated extraordinary publicity concerning its wonderful success in controling contagious abortion. The quadruped was granted entry into the U. S. by the federal bureau of animal industry as a healthy bull, capable of improving the dairy breed, and was accepted with alacrity by the veterinary officials of the proud state. It served no cows and exhibited no observed inclination to do so. Its sexual desire was about on a par with that of a freemartin and other cardinal signs of its being a bull were wanting. Abortion automatically ceased and the herd went dry, although both federal and state authorities had accepted the thing as a valuable addition to the dairy industry. The veterinary profession and the dairy husbandmen keep up such a loud and ceaseless din over *contagious abortion* that nothing can be heard concerning the basic principles of physiological reproduction.



A prize racer and her litter of nine puppies, estimated to be worth $1,000 each

Lecture No. 5.

The Puerperal Period in Relation to the Pathology of Reproduction*

IN THE preceding sections it has been aimed to show that physiological pregnancy can be established only by the mating of *two sexually healthy* individuals. It was further pointed out that after apparently physiological conception has occurred the pregnant female requires for the safety of her own genital health and of the health of her intrauterine progeny, that her nutrition and environment as a whole be physiologically maintained. It has been erroneously assumed by many that if a female conceives she is *a priori* genitally healthy. Hence in recording the results of handling a sterile female, the treatment is said to be *successful* if the female *conceives* regardless of what becomes of the pregnancy.

The pregnant uteri of cows, used for demonstration, showed various stages of gestation, and regardless of the period of pregnancy there were proofs of intrauterine disease in an important portion of specimens, especially after the fetus had reached 12 inches in length. The outstanding evidences of genital disease consisted of damages to, or destruction of uterine caruncles, the formation of adventitious placental structures and the presence of fetal diarrhea.

The Uterine Caruncles and Cotyledons

It has been stated by writers upon anatomy, obstetrics and abortion that the uterus of the cow, unlike other important organs, conforms to no fixed rules of anatomy, physiology or pathology, and is essentially an outlaw. That is erroneous. The bovine uterus conforms strictly to well established laws of form, structure and function. In Fig. 9 are shown two typical uteri of veal heifers. As soon as the fetus forms, the uterine mucosa is thrown into four major, and two minor longitudinal ridges. The four major ridges become divided transversely by a series of depressions which divide each ridge into about 30 segments, each of which is disc-shaped, pedunculated and with their greatest diameter parallel to the longitudinal diameter of the cornua. These constitute the caruncles (protuberance). When pregnancy occurs the caruncles undergo profound change, the growth of the caruncles is preponderantly transverse and their greater diameters shift from longitudinal to transverse as shown in Fig. 10. Sometimes, but not generally, the two minor ridges in the fetal uterine mucosa develop few or numerous caruncles. The major ridges may be designated lateral and median pairs. One of each pair is dorsal, the other ventral. The two minor ridges are on the middle line, one along the floor of the cornu, opposite the mesometrium, the other at the opposite side of the cornu, along the greater curvature. When this superior ridge develops, which is uncommon, a cow suffering from retained afterbirth may present the unusual feature of retention along the median line of the roof of the cornu.

Some high authorities have stated that the rows of caruncles vary; that there may be four rows in the gravid horn and perhaps only three in the non-gravid cornu. In a study of over 100 uteri of heifer calves,[19] each had the four major rows of cotyledons alike in both horns, and among pregnant uteri I have not

*The fifth lecture consisted of two parts. The first part was a demonstration based upon pregnant uteri from cows and sows obtained from the abattoir, and can not therefore be effectively included in the record. The second part was also extemporaneous, being based upon a series of lantern slides of healthy and diseased uteri and fetal membranes. The list of lantern slides was too extensive to warrant complete reproduction in this article. There is substituted a brief outline of the lecture in an effort to convey to the reader a fair conception of the character of these demonstrations and the principles they were aimed to teach.

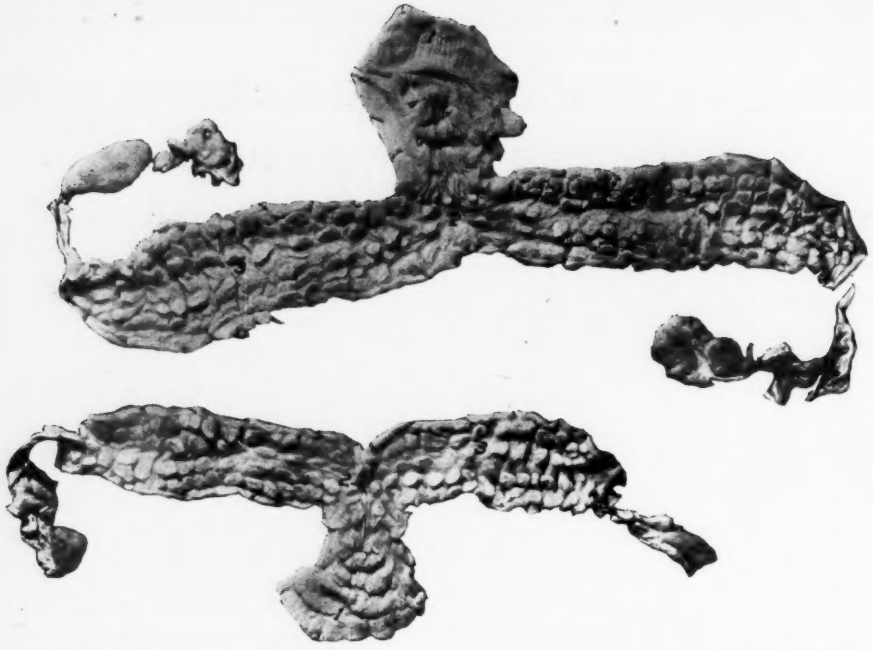


Fig. 9. ***Uterine Caruncles of Veal Heifers*****—1, vagina; 2, cervix; 3, right cornu; 4, ovary.**

Age of calves estimated at five to ten weeks. The inter-cornual ligaments, muscles and other tissues have been severed and the cornua spread at right angles to the cervix. The cornua have been incised along their greater curvature. The caruncles, as readily may be seen, are arranged in four rows with about 15 caruncles in each row of each cornu or a total of about 120. In the heifer calf and in the virgin heifer, the greater diameter of the caruncles corresponds with the longitudinal diameter of the cornua. The caruncles virtually consist of segments of longitudinal ridges in the uterine mucosa or endometrium. When pregnancy comes (See Fig. 10) the development of the cotyledons causes a shift in the diameters, and the greater diameter is transverse

It will be seen from these illustrations that the bovine uterus is without an actual body and consists of two horns and a cervix only. The *uterine body* commonly described by veterinary anatomists is essentially fictitious for ruminants but is maintained in an effort to preserve the analogy with those uteri which have a true uterine body

found one, except virulent disease had caused the disappearance of the caruncles in one horn, in which the four rows were not clearly traceable. When a specimen is not properly prepared in this respect, as in Fig. 19, which was made for a different purpose, the rows may be thrown into mechanical confusion. The error, of the authorities referred to above, regarding the number of rows of caruncles, is due, evidently, to their having used, for their study, badly diseased uteri, or to having improperly arranged their specimens.

A more serious error has arisen concerning the arrangement and physiology of the caruncles through a lamentable confusion in nomenclature, the two terms, *caruncle* and *cotyledon* being used synomously. When correctly used, caruncle (protuberance) signifies the elevations or protuberances shown in Fig. 9. When pregnancy occurs, there is developed a new tissue from the superficial cellular layer upon the summits of the caruncles. This new tissue grows out toward the "fetal cotyledon"—which is not truly a cotyledon—and the latter sends outgrowths into this new tissue in the form of placental villi or tufts, such as shown

in Fig. 13. These sink into crypts, shown in Fig. 10. The new-formed tissue, to the bottom of the crypts, constitutes the cotyledons. After pregnancy has closed, this special new tissue is reabsorbed and disappears in the adeciduates (cow, ewe, mare) or drops away with the fetal structures in deciduates (bitch, cat). In the confusion it has been stated that the caruncles of the healthy cow disappear after calving but this is incorrect; they persist until the end of life unless destroyed by disease. In this confusion some influential writers assert that caruncles which have been destroyed by necrosis are renewed in the next pregnancy. The statement is absolutely without foundation. The uterus of the cow can no more produce a new caruncle which has been destroyed than can the leg produce a new foot in case the original has been cut off. An understanding of these basic truths is essential to a comprehension of the pathology of the uterus. Writers upon veterinary anatomy regularly describe the ruminant uterus as consisting of two horns and a body. Figs. 9 and 10 show definitely that no uterine body exists but that there are two cornua, the caudal openings of which meet opposite the anterior (cephalic) end of the cervix.

Fig. 10. Uterus from a Heifer Estimated at 90 to 100 Days Pregnant.

Uterus prepared as in Fig. 9. 1, lateral side of gravid horn; 2, lateral side of non-gravid horn; 3, median side of the gravid horn; 4, median side of non-gravid horn. The uterine seal is seen midway between 1 and 2 The growth of the uterus due to pregnancy has served to increase the distance between the caruncles and the regularity of their arrangement in four parallel rows is brought out far more clearly than in Fig. 9. It is also evident that the greater diameter of the caruncles has shifted in pregnancy from longitudinal to transverse

Adventitious Placental Growths

When the lining membrane of the uterus has been seriously damaged by disease but not completely destroyed, it frequently produces a new growth of placental tissue. These are frail, irregular outgrowths which do not develop into definite caruncles. The tissue acts as a substitute for the physiological placentæ but is defective in its power to afford nutrition to a fetus. Sometimes when almost all caruncles have been destroyed,

these adventitious structures serve to supply sufficient nourishment to produce a viable calf, but almost always, if not in every instance, the calf is more or less premature and is small. The constant tendency is toward interruption of the pregnancy, as indicated in Fig. 15.

Fig. 11.—*Allantois-chorion from a sexually healthy cow.* The fetal sac has been incised along its greater curvature, between the two dorsal rows of caruncles. Shown from the endometrial (uterine) side. 1, the chorionic navel; 2, the cervix; 3, the non-gravid cornu The caruncles are regularly arranged in four parallel rows and the cotyledons are symmetrical in size and form. No adventitious placental formations are present

The pregnant uteri from the abattoir largely contained fetuses which had suffered from diarrhea. This is the rule in dairy cows; the amniotic fluid contains meconium. In early pregnancy it usually gives to the amniotic fluid a brownish color, and the fluid is turbid. Flakes of dark meconium float in the liquid. Later in pregnancy the meconium is yellow and when fetal diarrhea continues to or near birth the calf is born, or the dead fetus expelled, thickly smeared over with yellow, pasty meconium. In the ideally healthy fetus, the amniotic fluid is clear, very faintly straw-colored and contains no floating particles. Of all domestic animals, cattle have the greatest tendency toward diarrhea. Diarrhea is a prominent symptom in various diseases. It is common in most forms of sepsis and is very common in the later stages of septic metritis. So when toxic substances from a diseased placenta enter the fetal blood stream the fetus promptly responds with diarrhea. The fetal diarrhea, in the material at hand, was in complete harmony with the extent of placental disease. In each case where placental lesions were prominent, fetal diarrhea was present. In dairy cows, if adventitious placental growths are numerous, if there is extensive necrosis of the chorion, etc., fetal diarrhea is very likely to be recognizable.

The Fetal Membranes in Relation to the Pathology of Reproduction

In 1924, Udall, Frost and others with myself,[17] recorded extensive studies, in

which it was clearly shown, at least thus far without contradiction, that careful studies of freshly expelled fetal membranes, under adequate technic, reveal authentically the history of uterine disease in the past and present and enables the observer to make a reliable forecast of the breeding future of the animal; except new forces come into play competent to overpower the intrinsic powers of defense possessed by the individual. As already stated, while discussing observations upon abattoir material, the uterine caruncles are formed early in embryonic life and remain constant throughout life except they are destroyed or injured by disease. The contrast between health and disease is well shown in Figs. 11 and 12. That in Fig. 11 is from a highly fertile cow which regularly conceives at the first service, while Fig. 12 is from a poor breeder. The non-gravid horn (3) in Fig. 11 is proportionally much larger than in Fig. 12. This in itself reveals the comparative health of the two uteri from which they came, and shows that in Fig. 11 the fetus obtained a far greater and better nutritive supply from the non-gravid horn, than in Fig. 12. This variation in health, as indicated by the comparative volume of the non-pregnant horn, is recognizable upon rectal palpation in the pregnant cow and is very significant. The pregnancy in Fig. 11 is clearly safer than in Fig. 12, the duration of pregnancy will be more nearly ideal, dystocia will not occur in Fig. 11 but is probable in Fig. 12. The new-born calf of Fig. 11 will be vigorous and not so highly susceptible to diarrhea and pneumonia as that of Fig. 12 and will ultimately develop into a more valuable animal.

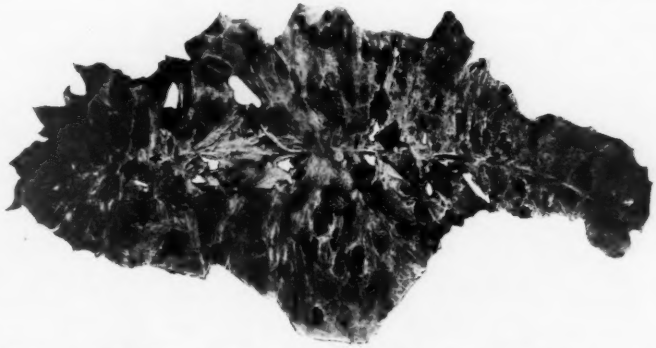


Fig. 12. *Allantois-chorion from a sexually unsound cow.* 1, the very small, naked non-gravid horn; 2, cervix; 3, chorionic navel; 4, ovarian pole of the gravid horn with adventitious placental growths. This cow required repeated breedings for conception. Some of her gestation periods were abbreviated, others prolonged. A comparison with Fig. 11 serves to explain, at least in part, the variations in the duration of pregnancy. The non-gravid horn, 1, from the cervix, 2, to its ovarian pole has been wrecked by disease associated with a prior pregnancy and can supply virtually no nutrition to the fetus—in the healthy uterus shown in Fig. 11, the non-gravid horn, 3, is fully supplied with healthy cotyledons, competent to contribute largely to the nutrition of the fetus, thus largely relieving the load upon the gravid horn

Fig. 12 illustrates nature's effort to compensate, through hypertrophy of one part for a loss of function in another portion of the same organ. As a substitute for the loss of function in the non-gravid horn, 1, the cotyledons in the gravid horn have grown to gigantic size and a further effort at compensation is made at the ovarian pole, 4, where adventitious placental development has occurred. Conception can not occur on the side which is non-pregnant in the gestation illustrated; if bred when ovulating on that side the service fails. The pregnancy in the less injured cornu is menaced by the overloading of the one horn and the lowered vitality of the damaged uterus. The cow is rendered subject to disaster under unfavorable conditions which would not threaten the life of a fetus in a healthy uterus like that shown in Fig. 11. The danger to the pregnancy can not be averted by the agglutination test and isolation, by the administration of living or dead Bang bacilli, or by feeding any vitamin or mineral. The damage to the uterus can no more be restored to normal than could the cow grow a new leg if one were amputated. The constant tendency is for the lesions to increase progressively in area with each pregnancy toward the condition illustrated in Fig. 14, which is the end of reproductive life

That is a small part of the picture.

Further study will show that the fetal placentæ or cotyledons of Fig. 11 are large and regular in the non-pregnant horn while in Fig. 12 they are absent in that area so that all nutrition must come from the pregnant horn, which diminishes the available food supply to the fetus.

The cow represented by Fig. 11 mated with a healthy bull should conceive at a single service whether the right or left ovary functions; Fig. 12 would fail to conceive if bred when ovulating from the ovary corresponding to the non-pregnant horn, and conception would be uncertain when bred at the time of ovulation from the other side. The placentæ of Fig. 11 are even in contour and the tufts or villi are very fine, packed closely together and show a delicate, velvety surface, while in Fig. 12 they are rough, coarse, uneven and clumpy. This is seen more definitely with the aid of a reading glass. The significance is more clearly brought out in Fig. 13, where a healthy cotyledon, (1) from membranes like Fig. 11, is placed beside an imperfect one, (3), from membranes like Fig. 12. In the cotyledon marked 1, the tufts or villi are extremely fine, and crowded closely together like fine velvet. This is in sharp contrast with cotyledon 3, in which the tufts or villi are few, coarse and in clumps. In some prior pregnancy the superficial, placenta-forming layer of the caruncle was damaged so that a large part of its area is functionless. In these damaged areas, crypts could not be developed in the caruncle and hence no tufts or villi formed in the fetal placenta. In those areas on the summit of the caruncle still capable of placental function, the crypts or cotyledonal depressions which form, are gross and yielding to the general laws, try to compensate for the missing crypts by increase in size. Accordingly the tufts on the fetal placenta, as shown at 3, Fig. 13,

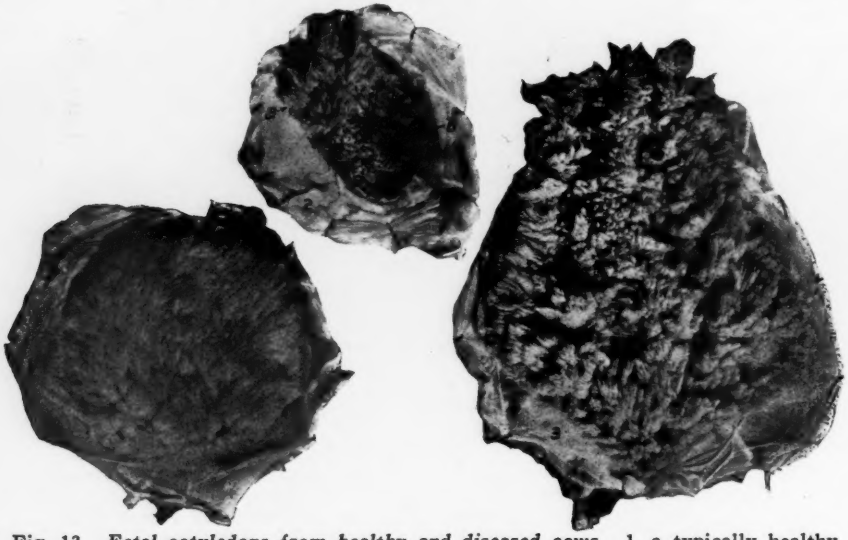


Fig. 13. ***Fetal cotyledons from healthy and diseased cows.*** **1, a typically healthy cotyledon with closely packed, very finely branched chorionic tufts or villi; 2, a cotyledon from a sexually diseased cow. The villi have been almost completely destroyed. A few coarse tufts remain at *a*, while at *b* the necrosis has completely destroyed all villi; 3, a gigantic cotyledon from the same cow as, 2, showing only very coarse, clumpy tufts with extensive naked (shown in black) areas**
The cotyledons have been specially prepared and arranged to show the chorionic tufts or villi in detail. The healthy cotyledon, 1, is illustrative of the type of organ shown in Fig. 11, while, 3, illustrates the type of cotyledon shown in Fig. 12

are large and coarse. They stand out two centimeters or more above the basal membrane from which they arise and leave the naked areas as depressions of equal extent. In the special photographic technic designed to show the tufts or villi, shadows are cast over the naked areas so that in 3, Fig. 13, they appear as black shadows; the shadows are areas without tufts, and the depressions with perpendicular sides (tuft masses) are about two centimeters deep. It requires no vivid imagination to see that 1, in Fig. 13 possesses far greater value as an avenue for nutritive supply to the fetus, than is possible for 3. At the same time the healthy, perfect organ affords greater security for fetal health.

The fetal membranes illustrated in Fig. 14 represent the maximum of uterine injury in which conception is possible, and the production of viable young is impossible. That is, there remained sufficient vitality in the placenta-forming tissues of the uterus for a fertilized egg to become located and obtain an extremely precarious nutritive supply for a brief period, but a wholly inadequate amount to supply nourishment sufficient in either quantity or quality to produce a viable calf. No healthy caruncles remain after the havoc caused by pyometra at the close of the prior pregnancy. The uterine mucosa of one horn has been completely destroyed and the cavity closed so that in the illustration it is represented by a dome-like projection, 1, which barely entered the base of the horn. At the ovarian end of the other horn, the placenta-forming tissue has been destroyed but the cavity of the cornu remains open, and there has projected into it a slender dia-

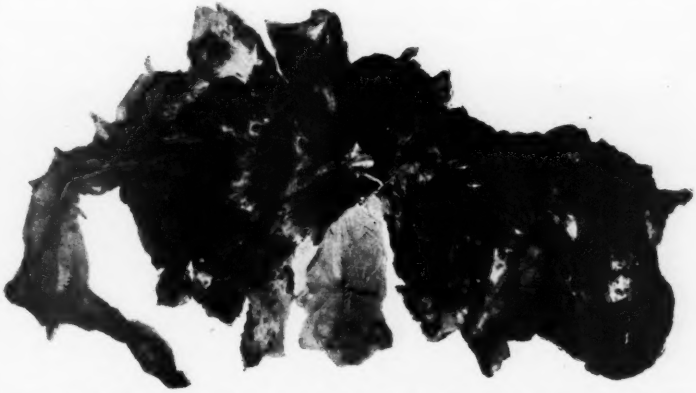


Fig. 14. *Allantois-chorion from a hopelessly damaged uterus.* 1, dome-like non-gravid cornu; 2, the amnion at the middle of the gravid horn; 3, prolongation of the gravid cornu of the chorion which had occupied the ovarian pole of the uterus. Prior disease had destroyed completely the endometrium in this region; repairs having been made by the formation of scar tissue, utterly devoid of placental function

The illustration demonstrates the extreme limit to which a uterus may be damaged by disease, and repairs be made, through the production of adventitious placental tissue, which may render conception possible. But the power of recovery is insufficient for the production of viable young. The next, and final stage of disease is the total destruction of the endometrium; then in my experience, the cow ceases estruation

The record indelibly engraved upon this allantois is:

1. The endometrium has been so completely destroyed in the non-gravid horn that the chorion failed to penetrate it except at the base where it forms a dome-like protuberance. The fetus was thus deprived of any possible nutrition from this horn except at its base

2. The endometrium at the ovarian pole of the pregnant horn, 3, has been completely destroyed and remains functionless. The chorion in this area is merely a diaphanous membrane, without nutritive value

3. The cervical pole of the gravid horn has lost all its caruncles but the endometrium has retained sufficient vitality to enable it to produce some frail adventitious placental growths which sustained fetal life for a time. The adventitious tissues are incapable of sustaining fetal development sufficient for the production of viable young

The reproductive life of the animal was definitely terminated by intrauterine disease. There could be no true cure of the sterility. Should the animal conceive, abortion could not be prevented by the agglutination test, by the use of living or dead abortion bacilli or by any imaginable means

phanous prolongation of the membrane, 3, devoid of function. Only the base of the pregnant horn and the very short, dome-like base of the non-pregnant horn, were able to produce some frail, extremely imperfect adventitious placental growths, incapable of supplying adequate nutrition or protection. The adventitious tissue consisted almost wholly of masses of weak, nonresistant blood vessels, from which blood in large quantities escaped from the vessels lodged within them; rendering the entire placental mass a deep black color.

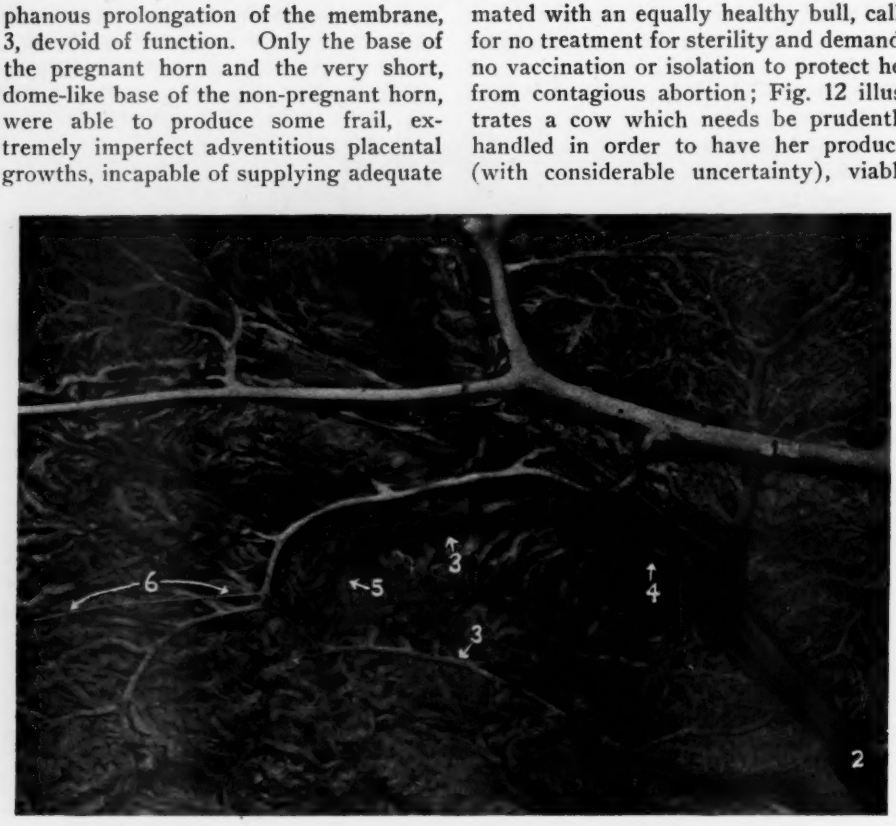


Fig. 15. ***Vascular Allantois of Mare.*** **The non-vascular, endodermic layer has been stripped off to show the intricate vascular network. 1, arterial trunk; 2, venous trunk; 3, ultimate arterial and venous trunks, giving off sinusoidal, or cavernous vessels, without themselves visibly decreasing in size; 4, secondary venous trunk; 5, a sinusoidal vessel, passing from artery to vein; 6, a very slender, non-branching artery As shown in the illustration, the placental villi are diffused over the entire chorionic surface instead of being concentrated in certain areas as in ruminants. Disease of the uterus in solipeds is revealed upon the chorion by means of highly inflamed areas, by patches devoid of villi because of necrosis and by more or less extensive necrotic areas of varying color, etc.**

These show briefly the fundamental importance of a healthy uterus, and the absolute necessity of perfect placental structures for physiological reproduction. A cow with fetal membrane like Fig. 11, mated with an equally healthy bull, calls for no treatment for sterility and demands no vaccination or isolation to protect her from contagious abortion; Fig. 12 illustrates a cow which needs be prudently handled in order to have her produce, (with considerable uncertainty), viable calves; Fig. 14 illustrates a case in which no known remedy for sterility and no isolation or vaccination against contagious abortion, or the use of any known sterility or abortion "cures" or nostrums can possibly restore breeding power—the breeding life of the animal has irrevocably ended.

The placental circulation, through the medium of which nutritive and waste substances are exchanged between the mother and her young, constitutes one of

the most intricate and interesting examples in the circulation of the blood in animal life. The two placental systems of vessels, maternal and fetal, lie in intimate contact, and through their extremely thin walls all nutritive and waste substances must pass between the pregnant female and her intrauterine young. The bounteous supply and intricate arrangement of these vessels may be visualized best by studying Figs. 13, 15 and 16. The delicately branched tufts in 1, of Fig. 13 consist essentially of finely branched blood capillaries. The somewhat larger arteries, veins and blood cavities with which the terminal capillaries communicate are most readily illustrated in the vascular allantois-chorion of the mare as indicated in Figs. 15 and 16. Disease in the terminal capillaries of these vessels soon involves the entire circulatory system of the placenta, deranges the functions of all the vessels, leads to aneurisms and various diseases of their walls, diminishes the nutritive supply, halts the growth of the fetus and menaces its health.

The influence of uterine lesions upon the health of the pregnant female and her intrauterine young is vividly illustrated in Figs. 17 and 18. In Fig. 17 is illustrated an enormous distention of the uterus from dropsy of the amnion and allantois. The pregnant horn of the uterus, (1), is tremendously enlarged; uncoiled it would be longer than the body of the cow. In Fig. 18 it is shown that the left, non-pregnant horn, (2), has no caruncles. These had been destroyed in connection with some prior pregnancy. This rendered the horn functionless. Unlike Figs. 12 and 14 the non-pregnant horn, (2), is enlarged almost to the size of the pregnant horn. It is a passive enlargement due to the mechanical pressure of the liquids. Similar conditions are sometimes encountered in extensive pyometra, the two horns being distended approximately alike. So far as now known, dropsy of the amnion and allantois always has extensive and serious lesions of the placental tissues of the uterus as its background. The lesions are not always the same. Dropsy of the amnion-allantois is common in badly raised heifers in first pregnancy, like those in Group C, Table IV., page 275. The le-

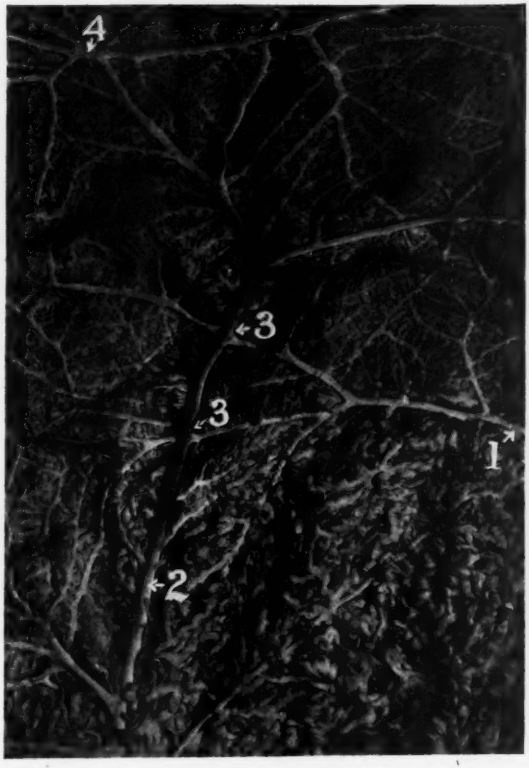


Fig. 16. ***Vascular Allantois of Mare.*** **Prepared same as Fig. 15 to illustrate the richness of arterial anastomoses near the median line of the greater curvature, opposite to the mesometrial attachment. 1, 2, arterial trunks; 3, ordinary and 4, multiple anastomoses Figs. 15 and 16 show more clearly than can be accomplished by any known technic which may be applied to the chorion of the cow to demonstrate the abundant blood supply of the placenta. Such placental circulation is fundamentally requisite to the proper growth of the fetus. Any interference with such supply endangers the nutrition and health of the fetus**

sions are then not the result of a prior gestation, but are a part of the existing pregnancy owing to the weak, imperfectly developed uterus. The principle involved is: so far as is yet known, dropsy of the amnion and allantois is uniformly the consequence of extensive and serious uterine disease.

The examination of the afterbirth of cows and mares affords the most secure basis yet discovered for the determination of the state of health or disease existing in the uterus at the close of pregnancy. It authentically reveals the past breeding history of the animal and the state of the uterus at the time when the placenta separated from it. In Fig. 12 it shows that the cow is an unsafe breeder and that her calves ordinarily will not prove typically healthy; Fig. 14 shows definitely that the cow can never successfully breed; and Fig. 18 indicates that the cow, had she recovered from the dropsy of the amnion and allantois, had only one-half the normal uterus, could not possibly conceive in the left horn, and conception in the right horn would be frail, an excessive load would fall upon the one horn, and seriously menace alike the cow and her fetus.

Like most means upon which to base a diagnosis and prognosis, the value of the record revealed by deciduæ lies in careful and conscientious study of them. The determination can not be made by rolling the afterbirth about in the gutter with a stable fork or by other high-speed, careless gestures. A definite technic[18] is to be scrupuously followed.

Fig. 17. ***Abdominal Viscera of Cow Showing Extreme Hydrops of the Amnion and Allantois.*** **1, right (gravid) horn, 12.5 feet long upon its greater curvature; 2, ovarian pole of non-gravid cornu lying upon the left hind leg; 3, mesometrium; 4, the empty rumen, displaced far forward; 5, omasum; 6, abomasum; 7, liver; 8, gall bladder; 9, large intestine; 10, small intestine; 11, left tarsus; 13, sixth right rib. (Cornell Veterinarian)**

The Examination and Handling of the Puerperal Female

The state of the pregnant uterus can be determined only to a limited degree,

until gestation has closed and with the fetus and its membranes out of the way, the interior of the uterus is available for direct examination. While as already stated, the proper study of the fetal membranes authentically reveals the state of the uterus, more reliably than the examination of the organ itself, the afterbirth is not always available. This is especially true in the cow, since she regularly eats

Fig. 18. ***Uterus from Fig. 17, Seen from the Endometrial Side.*** **1, gravid cornu with numerous cotyledons; 2, non-pregnant horn almost devoid of cotyledons; 3, cervix. Figs. 17-18 serve to illustrate the highly important truth that uterine and fetal diseases are parallel. Clinical evidence exists on every hand that a diseased uterus inevitably leads to fetal disease if pregnancy occurs, and any disease of the endometrial side of the chorion of the fetus indicates unerringly that corresponding disease exists in the endometrium. It is just as natural that a damaged uterus should lead to hydrops amnii, hydrocephalus, or other type of monster, or to dystocia or retained afterbirth, etc., as it is for a healthy uterus to produce a vigorous, healthy fetus at full term without difficulty. A fetus within a diseased uterus can pursue only a pathological course and reach a pathological end; only a healthy uterus can produce physiological young. Infection is certainly present in most of these pathological processes—it is almost certain that infection is present in all cases—and is the immediate cause of the injury, but it is, in a highly important sense, secondary to a fundamental damage to the organs, just as the tetanus infection is secondary to a wound. The basic cause reaches far back. In the case illustrated in Figs. 17-18 injury from some infection had occurred in connection with a prior pregnancy. Even then the infection could not have accomplished the damage except the uterus was in so weak a state that it could not withstand the bacterial invasion. In genital pathology it is essential that control shall reach back to the original cause instead of permitting the injury to take place and then attempt to restore tissues destroyed beyond renewal. In genital pathology of domestic animals the fundamental causes are to be sought chiefly in bad sexual hygiene, in disease acquired during fetal life or shortly after birth, in breeding immature young, or in sexually overloading the mature animal**

the membranes as soon as they come away and not infrequently tears off and eats the protruding portions while some parts remain.

Retained Afterbirth

In dairy cows, retained afterbirth is a vexed question. In the preceding pages certain principles of sex hygiene have been advocated which will go a long way to prevent its occurrence. When prevention has failed, highly satisfactory cure is impossible. Many methods of handling are recommended, but no plan has won the position of an accepted standard. The recommendations are as wide apart as the poles. Some advocate the early manual removal, although in many cases it is irremovable. Others go to the opposite extreme and leave it alone. Each case is an individual problem, always obedient to fundamental principles of pathology but modified by the extent and virulence of the disease present. Two fundamental principles should control the efforts.

1. The membranes are dead tissues, subject to putrefaction, and should be removed from the uterus at the earliest practicable date. It should be kept in mind that the tearing away of the contiguous chorion and leaving behind the placental or cotyledonal area over one or more uterine cotyledons is not the removal of the placenta. It should be equally remembered that when a portion of the membranes at the apex of the gravid horn is irremovable, the tearing away of the major part and leaving the apex to putrefy, is by no means the removal of the afterbirth. It is doubtful whether the remnant will come away as early and favorably as it would have done had the other portions been left to keep the cervix open and to exert gentle traction upon the irremovable part.

2. It is perhaps generally admitted, at least it seems difficult to controvert, that pending the expulsion or removal of the afterbirth, all available means should be applied to repress putrefaction. I have favored iodoform-bismuth-oil; others advocate charcoal and other substances. Their efficacy will depend upon the virulence of the disease processes, and the skill and attention used in handling. No remedy is ideal. Retained afterbirth leaves an indelible mark, and its effect upon the breeding health of the animal will vary with the virulence and duration of the disease process, the skill in handling, and other pertinent forces. One of the most common and unfortunate errors is the current attitude that once an afterbirth has been removed, the case is completed and the animal convalescent. Retained afterbirth is not a disease of the afterbirth but of the uterus, and the removal of the placenta has its principal advantage in the fact that it uncovers the diseased endometrium and renders the endometritis more accessible to local treatment.

The expulsion of the afterbirth leaves the entire placental area of the uterus denuded of protective epithelium. Bacteria or viruses are commonly present, although in ordinary pregnancy they have done no important injury. The dilated and abraded birth canal invites infection from without. When uterine disease follows the close of pregnancy, the more common types of bacteria or contagion within the uterus may be of either intrinsic or extrinsic origin. Puerperal tetanus occurs with sufficient frequency to indicate that extrinsic infection sometimes enters through the birth canal.

In the preceding pages I have definitely advocated an extended rest period between pregnancies upon the ground that it adds security by allowing ample time for the uterus to overcome infection present, to complete the process of involution and resume the physiological non-pregnant state. Observation teaches emphatically that mere rest (letting things alone) often fails to restore the genital system to an ideal state of health. Having this in mind, the question of prudent interference arises; in this field there is ample room for wide divergence of opinion. The current attitude is, that when genital disease thrusts itself forcibly

Fig. 19. *Gravid Uterus and Chorion from an Abbattoir Cow.* This uterus, with the chorion, shows clearly that extensive damage had occurred in connection with a prior pregnancy, but sufficient repairs had been accomplished that she was well advanced in pregnancy at the time of slaughter and was apparently competent to produce healthy young under favorable conditions. Under unfavorable conditions her pregnancy would be in jeopardy and might end in abortion, dystocia, retained afterbirth, etc.

The illustration is given in order to further emphasize the fact that upon the chorion is indelibly written an authentic history of health or disease of the uterus up to the time of the expulsion of the afterbirth. Although the uterus (lower figure) is somewhat contracted and disordered due to imperfect preparation, it is obvious that the chorion is a faithful replica of the uterus. In the uterine horn at the left are 35 fairly perfect caruncles; in the corresponding cornu of the chorion are also 35 cotyledons of the same size and arrangement. In the horn of the uterus at the right, which has been badly damaged in connection with a prior pregnancy, only 13 imperfect caruncles are visible; the corresponding horn of the chorion contains but 13 equally defective cotyledons. The anatomical arrangement of the caruncles and cotyledons is clearly demonstrated in the horn of the chorion at the left, but the uterus was less carefully arranged and while the four rows are recognizable, they are less clear.

The obstetrician can on no account afford to neglect the revelations of the chorion if he has any professional ambition to know the condition of the uterus. Palpation of the uterus per rectum, exploration of it through the cervix, and a study of the breeding record of the individual, are informative and highly desirable; *but for an accurate picture of the present condition of the uterus, an authentic record of its past experience and a dependable prophecy as to its future performance, no ascertainable information approaches either in scope or authenticity, that revealed to all who will read what is written clearly upon the recently expelled afterbirth*

upon the attention of the observer, it should be noted and, if in his judgment spontaneous recovery is improbable or impracticable, interference is to be considered. The opposite view, in the extreme is, that adequate effort be made to determine the presence or absence of disease without awaiting profound superficial evidences of important pathological processes within the uterus or other organs. When such search is made in dairy herds, it is found that a large proportion if not a great majority of puerperal cows reveal definite evidences of uterine disease. This having been determined, the problem inevitably arises if it were not better, at least in some dairy herds, to go yet one step further, and make an effort to forestall puerperal disease through preventive measures. In human obstetrics the preventive measures are primarily concerned with the prevention of invasion by extrinsic infection. While it doubtless does much to reduce, it does not eliminate puerperal infection in woman. In dairy cows, as well as in other breeding animals where the laws of sexual health are scorned, intrauterine disease is a prevailing accompaniment of pregnancy and the bacteria or viruses are not deported when the fetus is expelled. There is abundant and reliable evidence that bacteria or viruses may be present in the pregnant uterus without causing notable injury but acquire pathogenic power when the uterus has been denuded of its protective epithelium and has been profundly fatigued by labor.

As resident veterinarian I have had opportunity for constant and detailed observation in breeding studs and registered beef and dairy cattle. I have found that in cows, a detailed examination of the puerperal uterine cavity often reveals extensive disease which is not accompanied by any extrinsic signs: there is no elevation of temperature, no visible loss of appetitite, no extraordinary genital discharge or other signs of genital disease. I have elsewhere[21] described and illustrated a typical case involving extensive edema of the chorion in a cow. So far as the owner could observe, her puerperal period was perfectly healthy. She again conceived without delay. At near the close of her term she suddenly died because of rupture of the uterus due to an extreme edema of the chorion. The autopsy revealed that all caruncles had been destroyed in one horn, the same as is shown in Fig. 18. The evidence was clear that this injury had occurred at the close of her first pregnancy without having caused any external symptoms of a character to attract the attention of her owner, a highly intelligent farmer. Abundant cases of similar character occur and raise the important question of the prudence of making examinations of the uterine cavity following the termination of pregnancy and applying any available preventive measures. Such a course is clearly impracticable in a large proportion of domestic animals. In registered cows and mares of high value, especially where sexual disease of a virulent type is prevalent, the regular examination of the uterine cavity and the application of prophylactic handling may well assume definite economic value. In my experiences as resident veterinarian, the universal application of preventive measures immediately following the termination of pregnancy have proved of great economic value; have definitely reduced the virulence and prevalence of genital disease; have increased the fertility and the security of gestation; have decreased the difficulties of labor, and have raised the quality of the offspring.

My plan in cows has been to introduce a little warm physiological salt solution into the deepest portion of the uterine cavity, through a long, soft rubber catheter. The external end of the catheter is then compressed and lowered to the floor or ground, the compression released and the uterine contents siphoned out. That accomplished, bismuth-iodoform-mineral oil was introduced. The high specific gravity of bismuth and iodoform causes them to fall down to the lowest part of the uterus, in the area of greatest accumulation of exudate, and

without causing irritation, slowly to decompose in the presence of bacterial activity. Similarly, mercurochrome, 2 per cent in lanolim, and enclosed in gelatine capsules, may be deposited in the deepest part. Other substances probably possess equal value.

Summary

Reviewing briefly the thoughts submitted regarding the pathology of reproduction, it is urged that the prevention of genital disease be based upon the fundamental laws of sex hygiene. No era of life is free from dangers to the function of reproduction. There are certain points in the lives of breeding animals where the menace to genital health is especially notable. At these points protective measures should be concentrated.

1. Physiological reproduction demands the mating of two sexually healthy and vigorous individuals.

2. The new-born animal must be kept in the highest attainable state of health during the developmental period of its reproductive system. This applies with special force to dairy calves that are artificially fed.

3. The young animal should not begin breeding until it has reached sufficient maturity that it has ample reserves of nutrition and strength to safely carry the burden of reproduction. In the females the reserve strength and vigor should be not only sufficient to bear the load under expected conditions, but an ample margin of safety should be provided against unpredictable stresses—bad food, inclement weather, etc.

4. The male, like the female, should not be asked to assume a sexual burden of a character to menace his fertility. His fertility should be watched closely by means of examinations of his spermatozoa.

5. The female should be granted ample time for complete recovery and rest after the termination of a pregnancy before causing her to resume the burden of gestation.

6. The puerperal female should have the most skillful and abundant oversight which her economic value will justify.

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Nerves achieve their effects by means of special hormones which they produce instead of by direct action on muscles and glands.—*Science.*

People in the United States spend $15,000,000 a year on fraudulent cures.—Committee on Cost of Medical Care.

Eggs are better than a spring tonic in view of the iron, vitamines and protein they contain.—U. S. Bureau of Home Economics.

The gestation period of the fisher and marten is between 350 and 360 days, an astonishing long period for these small carnivorous animals of the weasel family.

An oil made from the liver of the food fish halibut, has a vitamine A content more than 100 times as great as that of cod liver oil.

There was a blizzard in Minnesota, Nebraska, Iowa, Illinois and Indiana early in March resulting in pig losses. It is believed that surviving pig crop of 1932 is about 20 per cent. less than that of 1931.

Crowther, a New York scientist, has discovered a way of making bacterins without the use of chemicals or heat, the bacteria in the suspension being destroyed by blowing them up with carbon dioxide as grains of wheat are puffed or pop corn is popped by expanding steam.

Observations made during two severe outbreaks of foot-and-mouth disease in Sweden led Forssman to the conclusion that virus carriers for more than three months after infection played no part in the spread of the disease. This finding if verified, may justify the quarantine rather than slaughter of valuable, exposed or infected animals in future outbreaks of foot-and-mouth disease in this country.

The virus of endemic typhus is present in rat fleas taken from wild rats caught at typhus foci. The rat flea *Xenopsylla cheopis* readily becomes infected with the virus of endemic typhus when allowed to feed on typhus infected rats. Infected fleas readily transmit typhus from rat to rat. The virus of typhus is present in the feces of infected fleas. Typhus may be transmitted by rubbing macerated infected fleas or the feces of infected fleas into the abraded skin of guinea pigs. Infected fleas may retain the infection for 52 days. In repeated attempts typhus was not transmitted by the bite of infected fleas when the feces were not allowed to come in contact with the skin of the experimental animals. There is no evidence to indicate that the virus of typhus may be transmitted to the offspring of infected fleas through the egg. Endemic typhus is not louse-borne; it is associated with contact with rats, and as it has its greatest prevalence in the late summer and fall, there can be little doubt that the rat flea *X. cheopis* is the important vector of endemic typhus of the United States. The flea is not simply a hoarder and mechanical vector of the virus of endemic typhus; the virus multiplies enormously in the body of the flea.

TISSUE CHANGES DUE TO HOG CHOLERA

The outstanding histopathological lesions of hog cholera is an encephalomeningitis, manifested by round-cell infiltration of the blood vessels of the menінges and brain, a proliferation of the glio-cells and degeneration of the nerve cells.

These encephelo-meningeal lesions were found in from 60 to 80 per cent of the cases of hog cholera investigated by Oscar Seifried of the Rockefeller Institute.

A second outstanding histopathological lesion in hog cholera consists of changes in the capillaries and small arteries and veins. This change comprised a proliferation of the endothelium, which may later

be followed by degeneration of the proliferation and of the normal endothelium. These blood vascular changes are responsible for the hemorrhages noted in various tissues in cases of cholera. They account for the hemorrhages into the lymph glands, kidneys, lungs and perhaps also the bladder and other structures.

Canine tuberculosis is frequently manifested by whitish circumscribed areas in the lung, liver, and kidney, There are no giant cells, epithelioid or small lymphoid cells in the canine tubercle. Felines are susceptible to infection with the bovine tubercle bacilli. Parrots and canaries are susceptible to the avian and human tubercle bacilli.—*Bio. Abst.*

The prevalence of bovine tuberculosis in the United States is now approximately 1.4 per cent. compared with 1.7 per cent. in 1930 and 4 per cent. in 1922. This reduction in bovine tuberculosis is disclosed by a survey just completed by State livestock sanitary officials and the Bureau of Animal Industry, U. S. Department of Agriculture.

Two recent decisions in Iowa courts upheld the Iowa State law requiring the tuberculin testing of cattle. In one case two farmers from Cedar County, J. W. Lenker and Paul Moore, were sentenced to three years each in the Iowa State Penitentiary at Fort Madison and were also assessed the costs of the trial. These men were convicted by a jury in a Jones County court for conspiring to incite Cedar County farmers to resist the testing of cattle for tuberculosis. The other court decision denied an application by G. H. Peverill of Waterloo, Iowa, for a temporary injunction enjoining the State Department of Agriculture from testing his herd of 44 dairy cows. The court declared that testing of cattle is a measure of public health and should not be delayed or stopped because of the remote possibility that a healthy animal may be negligently condemned or the test found not infallible.

Arizona, Utah, North Dakota and Minnesota prohibit compulsory vaccination against smallpox. Their combined population is slightly less than that of Massachusetts where vaccination is compulsory. During the decennium from 1919 to 1928 the four anti-states experienced 46,130 cases of smallpox; Massachusetts had 408 cases. To put it another way, 113 times as much smallpox occurred where compulsory vaccination is prohibited as where vaccination is compulsory. 60,000,000 persons died of smallpox in Europe during the 18th century. In 1792 Boston had a population of 18,000 of whom 10,000 had had smallpox. During that year there were 8,000 cases of smallpox in Boston.

OUTBREAK OF FOOT-AND-MOUTH DISEASE LIMITED TO SWINE

The type of virus responsible for the outbreak of foot-and-mouth disease in Orange County, Calif., late in April, appears to have been of low virulence. The disease has affected only swine. Although normally foot-and-mouth disease also attacks cattle, sheep, and goats, causing severe lesions, the virus responsible for the present outbreak of the disease has failed to affect these animals, a number of which have been exposed.

The low virulence of the present infection is paralleled by observations of two former outbreaks of the same disease in Gemany where practically all the cases were confined to the swine species, according to Chief Mohler. The present outbreak in southern California has been restricted to three foci of infection, in Orange, Los Angeles, and San Bernardino Counties. By May 7, ten days after the first diagnosis of the disease, all infected and exposed herds had been slaughtered, and buried. At this writing the disease appears to have been eradicated within ten days of its first diagnosis—an all time record in this respect.

The average per capita consumption of meat and lard in the United States was 147.7 pounds in 1931. This was 1.1 pounds more than in 1930, but was 2.2 pounds less than the average for the twenty year period from 1910 to 1929 and 4.9 pounds less than for the thirty year period from 1900 to 1929. In 1931 there was an increase of about one pound in mutton consumption, eight pounds in pork and lard, and a decrease of 14 pounds of beef and veal compared with the thirty year period average from 1900-1929.

A type of streptococci occurs in the joints and in the blood of patients affected with chronic articular rheumatism according to Burbank. These streptococci can be isolated from the blood only by a special technique. A condition similar to the articular lesions in chronic rheumatism was produced in rabbits by the injection of cultures of these streptococci. If the joints are infected with these streptococci the removal of the teeth and tonsils will be of little or no value. The most effective treatment is by means of a vaccine.—*Science.*

Five normal humans were fed pasteurized milk to which had been added different strains of *Br. abortus.* Only one case developed symptoms similar to undulant fever and this case was fed two strains of *Br. abortus* of porcine origin. Another similar experiment also resulted in the development of symptoms similar to undulant fever in one human that was fed *Br. abortus* (porcine). In both of these experiments the patients were fed the cultures until the Brucella organism could be isolated from the feces. "Failure to produce a similar condition with bovine strains is evidence against the bovine variety being the etiologic factor in undulant fever, but this evidence should not meanwhile be considered conclusive."—Porto Rico *Journ. Public Health.*

Way back in 1879 when hog cholera was a young but active menace to the swine industry, H. J. Detmers stated: "How cholera should and ought to be treated the same as rinderpest or cattle plague, pleuro-pneumonia or lung plague, glanders or farcy. The most thorough and decisive measures are in the end cheapest."

Foot and mouth disease has been eradicated effectively on each of its appearances. If hog cholera had been treated in the same way, the saving since 1879 would have made a good down payment on our agricultural debts. Instead, we are, in many States, letting all who wish to, use virus in treatment procedures. Big fires are usually caused by starting little ones—likewise, virus must be controlled before cholera can be eradicated. —Mark Welsh.

SANITATION SAVES PIGS AT NAVAL PRISON FARM

Adoption of the McLean County system of raising pigs at the U. S. Naval Prison Farm, Parris Island, S. C., has practically eliminated the mortality of young pigs.

The pigs grow normally and develop to maturity at least two months earlier than before the sanitation system was adopted. The pigs grow without losing their pig fat, the bones develop normally, and there are no stunted individuals in any of the litters. Until the installation of the system, about 50 per cent of the livers were unfit for food but since practicing sanitation, practically none have been unfit and kidney worms have been reduced to a minimum.

The swine sanitation system, consists essentially in washing the sows before farrowing and placing both the sows and their litters on clean pastures, thus preventing infestation of the young pigs with roundworms and other injurious parasites. It is widely used among hog raisers in the Corn Belt.